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MICROSCOPICAL DIAGNOSIS.

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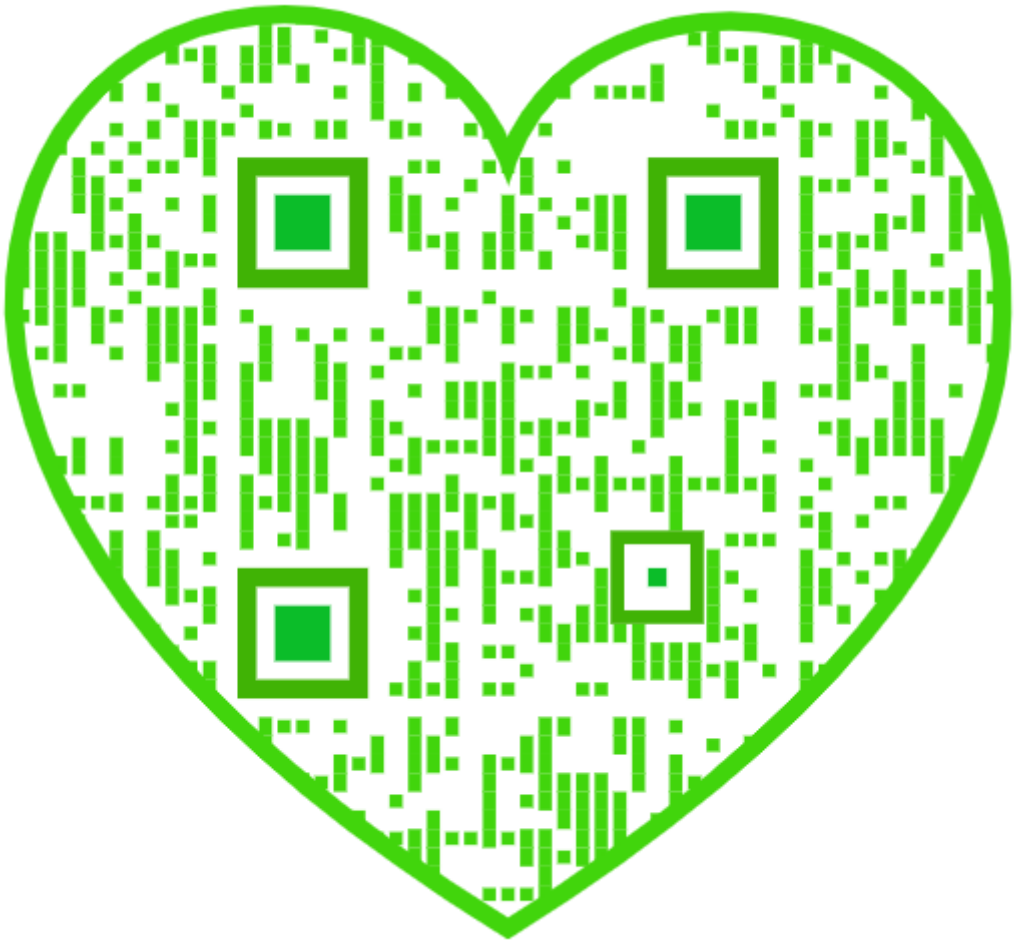

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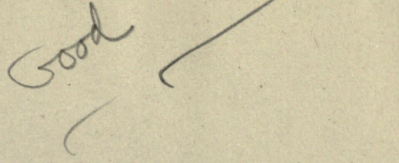
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MICROSCOPICAL DIAGNOSIS

—BY—

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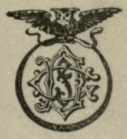
Illustrated with one hundred and twenty-eight Engravings on wood, and forty-seven figures on stone.

TOTAL NUMBER OF PAGES 250.



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PREFACE.

It has been my good fortune to be so situated during the past few years that my entire time has been devoted to the study of histology and microscopy, with special reference to the microscope in its relation to the practice of medicine.

Each year has accumulated the proofs that a good knowledge of the use of the microscope is of the first importance to the student of medicine, whether an undergraduate, or a practitioner in private or hospital practice.

Two reasons are generally given by our physicians as excuses for their ignorance of this important branch; lack of skill in the manipulation of the instrument, and the great outlay of time and money.

It is a fact that our busiest practitioners are the ones who give the profession the most knowledge through the press. It is also a fact that among these same men are found those who do so much work with the microscope.

I am convinced that those physicians who do not use the microscope are either totally devoid of any desire to advance in their profession or are lacking the necessary qualifications to enable them to appreciate the useful and practical.

I hold the great majority of the medical colleges of this country directly responsible for the lack of this love for scientific research. They seek to please the students by prejudicing them against the scientific investigation of disease; and the students become practitioners before they are aware of their ignorance of matters that should have been familiar to them during the term of their pupilage. A few strong men are commencing to express themselves in favor of microscopic inquiry, but to the coming physician must we, as microscopists, look for a solution of the more exact nature of disease and the more effective methods for its prevention and cure.

Scientific work does not unfit a man for practical work, and I take the liberty to prophesy that the physician of the future must be a scientific man or he will not be called a practical man.

I believe I show in the first part of this work that the microscope is not only eminently useful but also absolutely necessary for the correct diagnosis of certain, not uncommon, forms of disease.

A careful study of the first chapter will enable any one of ordinary

intelligence to understand the manipulations of the instrument sufficiently well for him to go to work without delay, and then with the aid of the illustrations he will be able to recognize the various forms described in the following pages.

The illustrations for the chapter on "Urinary Deposits" were prepared with unusual care. The strictest attention was given to the most minute detail in the preparation of the original specimens. As soon as prepared they were given to Mrs. Stowell, who made the drawings with her acknowledged accuracy. These drawings were then given to the engravers with instructions to carry out the artist's design in every particular. The proofs were carefully examined, and as a result I feel assured that neither more beautiful nor more accurate representations of the various urinary deposits have been offered to the public.

The second part of the work consists largely of original articles contributed by Mrs. Stowell during the past two years to prominent journals.

This work in Vegetable Histology has been sadly neglected in this country. It is Mrs. Stowell's purpose to add, from time to time, to the present list of subjects until it shall embrace the great majority of the medicinal plants. It is the beginning of a task never before attempted in this country, and the beauty and truthfulness of the drawings together with the text are sufficient to class it as an unique contribution to our meagre knowledge of Vegetable Histology.

The articles on "The Study of Wheat" originally appeared in the *American Miller* of Chicago.

The articles on Eucalyptus Globulus, Jaborandi, Sarsaparilla, Fucus Vesiculosus and Ustilago Maidis, were contributed to *Leonard's Illustrated Medical Journal* of Detroit.

The articles on Boldo leaves, Alstonia Scholaris, Folia Carobæ and Jamaica Dogwood, appeared in *The Therapeutic Gazette*, of Detroit.

Thanks are due to the editors of these journals for the use of the cuts illustrating the text.

Dr. Leonard also loans the cuts illustrating the chapter on "The Microscope in Skin Diseases"; these cuts were made for his work on "The Hair."

Mr. Fred. K. Stearns, wholesale druggist, of Detroit, has shown similar favors.

CHAS. H. STOWELL.

"HISTOLOGICAL LABORATORY,"
UNIVERSITY OF MICHIGAN.
OCTOBER, 1882.

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PART I.

PART I

The Microscope.

MICROSCOPES may be divided into two general classes, simple and compound.

The simple microscope is used for coarse dissections of small objects, and for the purpose of obtaining a general view of the specimen.

With a simple microscope we see the magnified image of the object; the rays of light proceeding directly from the specimen itself to the eye.

A simple microscope may consist of but a single lens, although two or more lenses are frequently employed. These lenses are so arranged that they act upon the rays of light as a single lens.

A valuable form of a simple microscope is that known as the "Coddington" lens. It consists of a sphere of glass with a deep groove in its equatorial part, filled with opaque matter. While this opaque matter limits the central aperture, yet it allows of the admission of considerable light, and gives a large field good in every part.

The "Stanhope" lens is another form of a simple microscope. It differs from the "Coddington" lens in that its two convex surfaces are of unequal curvatures. These surfaces are separated by a quantity of glass of such a thickness, that when the more convex surface is turned toward the eye, any object placed on the less convex surface will be exactly in focus. A good "Stanhope" lens is a convenient form of a pocket-magnifier, although for this purpose we have not found it equal to a first-class "Coddington."

For the small sum of two dollars one can procure a "Coddington" lens, well mounted in brass, giving plenty of light, and having a large field, suitable in every way for the office table; while for five or six dollars a lens can be purchased, elegantly mounted in silver or aluminum bronze, and especially adapted for a pocket-magnifier.

The simple microscopes offered by dealers as "dissecting" microscopes, frequently have one or more "Coddington's" as a part of their outfit.

While a single lens is all that is required to constitute a single microscope, two lenses, at least, are required for the compound microscope. One lens is required to form an enlarged image of the object, hence called the objective; and another lens to magnify this enlarged image, and as this lens must be placed nearer to the eye than the former lens, it is called the eye-piece, or ocular.

Thus the image is inverted. This, however, can be remedied by placing between the objective and the eye-piece a set of lenses, known as the erector. This causes the object to appear in its natural position, as in the simple microscope. We cannot recommend this accessory to either the novice or the expert.

The stand of a compound microscope includes all the framework to which the eye-piece and objective are attached.

Stands are sold separately by many makers, although one or more eye-pieces usually accompany them. This is very convenient for the purchaser, for he is now free to make his own selection of objectives.

A stand usually consists of the following parts:

The Base or Foot (Fig. 1) "A," the part which gives support to the rest of the stand. The base should be heavy enough to make the instrument rest firmly on the table, especially when inclined for the camera, and it should rest upon three points only, giving the tripod form.

The Body "B," that part to which the objective is attached. It should be supplied with the "society screw," in order that any standard English or American objectives may be used with it.

The Draw-tube "C," which slides within the body.

Nearly all the better stands are provided with single draw-tubes, while some have double tubes, thus giving greater range of magnifying powers.

The Arm "D," a support for the body. This is usually broken by a joint, in order that the instrument may be inclined to any angle with the horizon.

The Collar "E," a tube surrounding the body. This is not present on many stands.

The Coarse Adjustment "F," for coarsely and quickly focusing

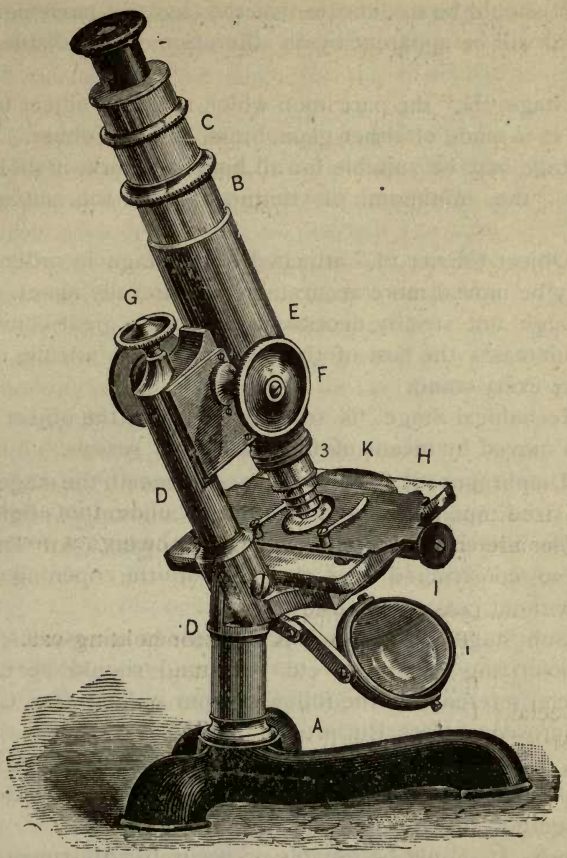


Fig. 1. Compound Microscope. (*Bausch & Lomb.*)

A, the base or foot; B, the body; C, the draw-tube; D, the arm; E, the collar; F, the coarse adjustment; G, the fine adjustment; H, the stage; I, the object-carrier; K, the diaphragm; 1, the mirror; 2, the eye-piece; 3, the objective. (Cut one-third of actual size.)

the instrument. The coarse adjustment is affected in the cheaper stands by sliding the body within the collar. The microscope shown in the engraving has the "rack and pinion" coarse adjustment. In some stands this adjustment consists of a delicate watch chain, controlled by a large milled head, on either side of the tube.

The Fine Adjustment "G." This is one of the most essential parts of a stand, and it should be carefully examined by the pur-

chaser. It should be so delicate that the slightest movement of the milled head will be apparent by an alteration in the distinctness of the image.

The Stage "H," the part upon which rests the object to be examined. It is made of either glass, brass, or hard rubber. In order that the stage may be suitable for all kinds of work, it should have combined "the minimum of thinness with the maximum of strength."

The Object-Carrier "I," attached to the stage in order that the object may be moved more accurately and carefully about.

Although not strictly necessary, yet it is a great convenience, and as it increases the cost of the instrument but a trifle, it should accompany every stand.

A "Mechanical Stage" is so arranged that the object can be accurately moved by means of finely adjusted screws.

The Diaphragm "K." This is placed beneath the stage and has different sized openings to regulate the amount of light. The smaller holes are employed with the higher powers. An "Iris diaphragm" is so constructed that the size of the opening may be changed without ceasing to observe.

The Sub-Stage is used for holding various accessories; as condensers, polarizing apparatus, etc. A stand should be examined with especial reference to the following four points; (see Carpenter on the Microscope. 6th Ed. p. 47.)

First. The optical parts and the stage should be so disposed as either to be altogether free from tendency to vibration, or to vibrate together.

Second. It should be capable of accurate adjustment to every variety of focal distance, without movement of the object.

Third. It should be capable of being placed in either a vertical or a horizontal position, or at any angle with the horizon, without deranging the adjustment of its parts to each other, and without placing the eye-piece in such a position as to be inconvenient to the observer.

Fourth. Simplicity in the construction and adjustment of every part.

The Mirror "1." It should consist of two surfaces; a plane surface, to reflect the light just as it falls upon it, and a concave surface, to converge the rays.

The Mirror-Bar should swing with an easy and firm motion to any obliquity. On some stands the mirror-bar is so arranged that it can be raised over the stage for the illumination of opaque objects.

The Eye-piece "2." The one most generally used is the Negative or Hughenian eye-piece. It consists of two plano-convex glasses, with the convex sides directed downward, and placed at a distance from each other equal to one-half the sum of their focal lengths. The lens nearest the eye is called the eye-glass, and the one more distant from the eye and nearest the field, the field glass.

A positive eye-piece differs from the above in that the field glass has its convex surface directed upward.

A Diaphragm is placed between the two glasses of the eye-piece, in the visual focus of the eye-glass.

A solid eye-piece is really a Stanhope lens. It gives a large field and clear definition. Eye-pieces are generally lettered in this country and numbered abroad.

In lettering eye-pieces, "A" represents the lowest magnifying power; hence it is known as a "low," or "shallow" eye-piece. In numbering, "1" corresponds to "A."

An "A" eye-piece then might be known as an "1 1-2 inch," a "low" or "shallow" eye piece; while a "D" might be known as an "1-2 inch," a "high," or a "deep" eye-piece.

As an eye-piece magnifies the image formed by the objective so will it magnify the imperfections of the objective. It must be apparent, therefore, that high or deep eye-pieces should only be used with the very best of objectives.

The Objective "3." This is the most important part connected with the microscope.

Objectives are numbered according to their equivalent focal lengths. Thus, by an one-fourth inch objective we mean an objective whose magnifying power is the same as a simple lens with a focal distance of one-fourth of an inch. It is a fact, however, that the objectives constructed by different makers and said to be of the same focal lengths, differ from each other in magnifying power to a considerable extent.

The shorter the equivalent focal length the "higher" the objective, and the greater its magnifying power.

An objective is composed of one or more systems of glasses.

It is not made of a single glass because the powers of refraction and dispersion are not equally united in any single refracting medium. Now crown and flint glass act with regard to each other in such a manner that if a crown glass lens be united with a flint glass lens, the refraction of the former will be lessened by the dispersive action of the latter, while the color dispersion of the former is neutralized by the opposite action of the latter. Thus by combining these glasses the aberrations are remedied to a large extent.

In the case of our figure the lower plano-concave lens is made of flint glass, and the upper bi-convex lens of crown glass. These two glasses constitute, in this case, a system, and in fig. 2, three of these systems complete the objective. These systems are mounted in either brass or hard rubber, which, at its upper extremity, is provided with a screw of standard size. Such a sized screw is termed a "society screw." All the first-class stands are so made that the body will receive any objective provided with the standard screw.

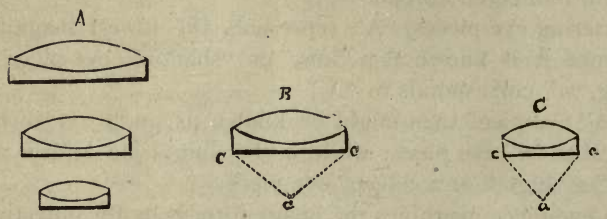


Fig. 2.

A, Achromatic objective of three systems; B, objective with high angle of aperture; C, objective with low angle of aperture. The angle of aperture is the angle c a c.

When estimating the comparative value of different objectives the following "good qualities" should be considered:

1. Defining power.
2. Resolving power.
3. Working distance.
4. Flatness of field.

Defining power is, without question, the most important quality to be sought in a lens. Its presence makes the objective of great value and its absence renders it simply worthless. It depends upon the completeness of the corrections for spherical and chromatic aberrations, especially the former. Defining power gives a clear, distinct and sharp outline to the image. Its absence is denoted by haziness, indistinctness and a general want of clearness. As any

imperfection in the objective is exaggerated by using "deep" eye-pieces, so any imperfection in the defining power can be thoroughly tested in this way; for an image which appears clear and distinct with a low eye-piece may be found to be very deficient under higher amplification.

Spherical aberration exists when the peripheral and central rays do not actually reunite in a single point. Those rays passing near the periphery, being more strongly refracted, come to a focus sooner than those which pass through the more central portions. Now if

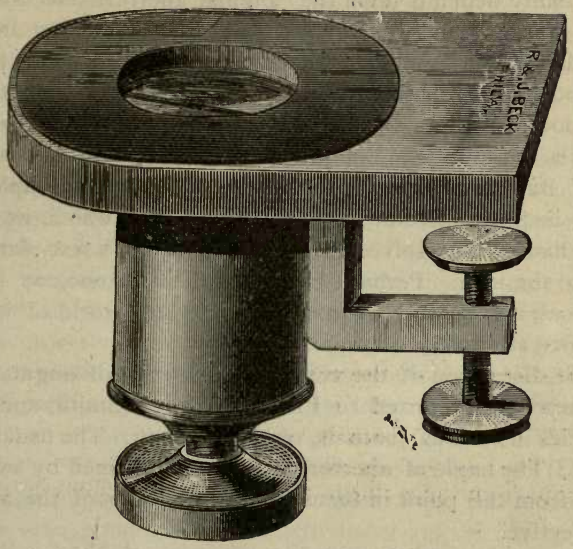


Fig. 3. Microtome. (*R. & J. Beck.*)

some parts of a lens bring the rays to a focus sooner than other parts, then the lens will magnify unequally, thereby distorting the figure. This distortion is present with all objectives not properly corrected, causing what is known as "aberration of form."

Chromatic aberration exists when a ray of light is not refracted as a whole, but is decomposed into rays of various colors, which being refracted to different degrees, give rise to a spectrum.

All objects examined now are seen fringed with colors. An objective is called "achromatic" when it is free or nearly free from this aberration. It is impossible to perfectly remedy these two

aberrations, but by the use of the two kinds of glass already mentioned they are nearly obviated. Objections thus made are said to be "corrected."

An objective is over-corrected when it shows a bluish border and under-corrected when it shows a reddish border, and as the blue color is the more agreeable to the eye, so all objectives are slightly over-corrected. While defining power shows the outline of a specimen well, resolving power enables the observer to detect the most intricate structure on its surface. Every practical worker is aware that this quality depends upon the "angular aperture" of the glass. Given two glasses equal in all respects but that of angular aperture, and that glass having the widest or highest angle will give the best resolving power. Professor Abbe says that the maximum attainable resolving power, with an angular aperture of 180° should separate 118,000 lines to the inch. Yet just at this time Mr. Ed. Bausch, of the firm of Bausch and Lomb, of Rochester, N.Y., has completed an one-eighth inch objective of high angular aperture which, in Dr. Up de Graff's hands has resolved the band on Fasoldt's test-plate 152,400 lines to the inch. Perhaps Fasoldt with his 1,000,000 lines to the inch may not be able to conquer the whole world of working microscopists after all!

For the discussion of the vexatious question of angular aperture, the reader is referred to Frey, Carpenter, Smith, and to the many articles in various journals, on that subject The usual definition is this: The angle of aperture is the angle formed by two lines extending from the point in focus to opposite sides of the aperture of the objective.

Working distance is the distance between the front glass and the point in focus. While even in the lower powers working distance is a desirable quality, yet in the case of the higher powers it is of essential importance. It is here that the immersion systems are so valuable, giving an increase in this distance. Penetrating power enables us to look deep into the structure of an object.

Carpenter says it may be defined as consisting in the vertical range through which the parts of an object not precisely in the focal plane may be seen with sufficient distinctness to enable their relations with what does lie precisely in that plane to be clearly traced out. Professor Abbe says that, theoretically,—the plane of construction remaining the same—the "penetration" of an objective

decreases, as the square of the angular aperture increases. This quality of an objective is exceedingly desirable, even essential for some kinds of work; hence different observers over or under-value it according to the nature of their work.

The "field" includes all the circle of light presented to the eye through the microscope. It is said to be flat when the object shows equally well over every part of the field, without changing the adjustment. If the field be perfectly flat, then the lines of a stage micrometer should be equally as sharp and distinct at the periphery as at the centre.

Having reviewed, briefly, the stand, the eye-piece and the objective, we are now prepared to answer the question—what microscope is best adapted to the needs of the busy practitioner and the no less active pharmacist?

The expert is able to choose for himself; we only venture advice to the inexperienced. In the first place, the stand should have a good, smooth, coarse adjustment, with as perfect a fine adjustment as it is possible to obtain. An object-carrier or movable stage is very desirable. Two eye-pieces should accompany the stand, and an "A" and "C" cr Nos. 1 and 3 will meet the demands.

Two objectives will answer all purposes for a long time. Our experience would say: Purchase an one-inch objective of about 25° angular aperture, and an one-fourth inch of about 100° angular aperture; or a three-fourths inch of about 35° and an one-fifth of about 100°. These are not expensive glasses, and yet they will do fine enough work of the kind for which they are recommended. We have seen good glasses of still lower angles. Having taught over four hundred students a year, for a number of years, practical laboratory work, and having purchased for them a very large number of microscopes, we are prepared to believe that an instrument as described above, is one of the best outfits of the kind a physician or pharmacist can purchase.

Such an instrument, with a few accessories, as a condenser, forceps, slides and covers, can be purchased for a sum ranging between $50 and $75. Thus the old excuse that "too great an outlay is needed at the start," will no longer remain valid; and with such a number of hand-books in the market the beginner need not suffer for helps.

From the great list of accessories a few only must receive

notice. A nose-piece will prove one of the most useful accessories that the working microscopist can possess. By the aid of this, a low power can be used for finding the objects. when without delay it can be examined with a higher power.

A camera lucida or neutral tint reflector is useful for purposes of drawing. As seen in the figure, the image is thrown upon a piece of paper where its outlines may be traced. The prism contrived by Dr. Wollaston is the one in most general use. It can be

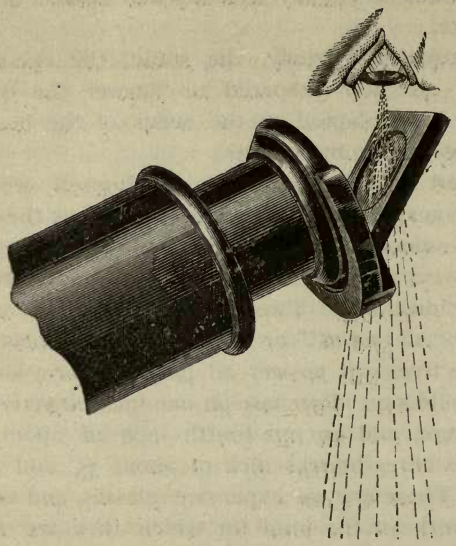


Fig. 4. Camera Lucida, or Neutral Tint Reflector. (Bausch & Lomb.)

purchased for about $6.00. As a substitute for a neutral tint reflector, Mr. T. B. Jennings recommends the following: A hole is cut in a flat cork, of sufficient size so that the cork just slips over the end of the eye-piece without its cap. A transverse slit is made beneath the hole and a common cover-glass inserted, at an angle of 45° to the optical axis of the microscope.

An eye-piece micrometer is a very useful accessory. Knowing the value of the spaces to which it is ruled, objects can be accurately and quickly measured. Of course the relative distance between the rulings will depend upon the objective used, the length of the tube of the microscope, and the eye-piece. By always using the draw-tube

fully extended, the length of the tube will be fixed, and with the aid of the stage micrometer the value of the spaces of the eye-piece micrometer for the various objectives and eye-pieces, is reckoned once for all. This is done in the following manner: Bring in focus the lines of the stage micrometer, place the eye-piece micrometer in

Fig. 5. Eye-Piece Micrometer. (*Increased one-third.*)

its proper position in the eye-piece, notice how many spaces on the eye-piece micrometer cover a single space on the stage micrometer, then divide the distance between two lines on the stage micrometer by the number of spaces covered on the eye-piece micrometer; the result will be the value of each space on the eye-piece micrometer for that particular ocular and objective.

Using the one-fourth inch objective and "C" eye-piece, we will assume that five spaces on the eye-piece micrometer cover one space on the stage micrometer—1-1000 of an inch—then one space on the eye-piece micrometer would be equal to one-fifth the value of the five spaces, viz., 1-5000 of an inch.

Now remove the stage micrometer and place in the field a specimen of blood for instance, and a white blood corpuscle is seen just to cover two spaces on the eye-piece micrometer; it is the 2-5000 of an inch in diameter.

A number of additional accessories will be added to the microscopists' outfit as their demand becomes manifest.

There are several methods by which the magnifying power of a microscope can be determined. The following are convenient: Incline the instrument until the centre of the eye-piece is ten inches from the table; the lines of a stage micrometer are then accurately focused; by means of a camera lucida or neutral tint reflector the magnified image of the lines is thrown upon a sheet of paper resting on the table just beneath the eye-piece. The eye is placed as seen in the figure, and the lines are traced with a pencil and their distances

from each other measured with a scale; this distance is divided by the distance between the lines on the stage micrometer, and the result will be the number of diameters. Or, place a scale in front of, and ten inches below the eye-piece; by looking in the instrument, keeping both eyes open, the lines of the stage micrometer can be seen resting on the scale, when their distance apart can be measured; divide this distance by the distance between the micrometer lines, and the number of diameters will be given.

The magnifying power of a simple microscope is ascertained as follows: The lens is placed on a rest of such a height that its upper surface will be ten inches from the table; a scale is used as a specimen; one eye being closed the other is applied to the glass, and the markings on the scale carefully focused; upon opening the closed eye the scale will be seen resting on the table; the distance between the lines as measured on the table is divided by their known distance on the scale, giving the number of diameters magnified.

Having no eye-piece micrometer, the size of any object is obtained in the following way: The image of the specimen to be measured is thrown down upon paper by means of the camera lucida, as were the lines of the micrometer, and carefully measured; this measure is divided by the magnifying power of the microscope, giving the real size of the specimen. Or, the size of the object may be ascertained in the same way the magnifying power was obtained, by holding a rule ten inches below and in front of the eye-piece.

A microscope is said to be in focus when the relative positions of the object and objective are such that the image is distinct. The following rule should be observed in focusing: Incline the head until one eye is on a level with the stage; with the coarse adjustment place the objective near the cover glass, too near to be in focus, then, while looking in the microscope, focus up. Never focus down. If this rule be carefully observed, the breaking of cover glasses and the destruction of specimens will be materially diminished.

Artificial or natural light may be used for purposes of illumination. For general microscopical work good daylight is to be preferred to any other kind of light. Not the strong sunlight, which is useful only under certain circumstances, but such an even, steady light as can be found by a window looking to the north.

Nothing can take the place of this northern light, both when

the sky is clear, and when, best of all, the sunlight is reflected from a white cloud. While artificial light is generally inferior to daylight, and weakening to the eyes, direct sunlight is positively injurious. Still, good lamplight is to be preferred to poor daylight.

When the light passes directly through the specimen and microscope, not reflected by the mirror, it is said to be direct. If the mirror is placed so that the reflected rays are in the optical axis of the microscope, the light is said to be axial or central. If the mirror be turned to one side so that the rays pass through the object at an acute angle, oblique light is obtained. In the illumination of opaque objects, when ordinary daylight or lamplight is allowed to fall on the object without any means of concentration, we have diffused light. When it is desirable to have stronger illumination, some means of concentration must be employed. For this purpose a bull's-eye condenser is used. This consists of a plano-convex lens, either mounted on a stand or attached to the stage of the microscope. It should be placed at right angles to the direction of the illuminating rays, with its plane side toward the object.

In the care of the microscope the following practical hints may not be out of place:

When removing from or placing on the stage a specimen, if the higher powers are in use, always raise the body of the instrument.

It is rarely necessary to clean a good microscope. Always use soft chamois, well beaten, or silk to clean the instrument with, and camel's hair brushes to remove dust.

To remove balsam, etc., from objectives, moisten the chamois slightly in alcohol or benzole and carefully wipe it off, remembering that any excess of the solvent may work around the lower glass and dissolve the balsam that unites the glasses of the lower system. Handle the instrument as little as possible, always carrying it by the arm.

Clean immersion objectives thoroughly and immediately after using.

When the instrument is not in use it should be placed in its case or under a bell-jar.

A microscope will suffer more injury at the hands of a careless and dirty person in twenty minutes than it need sustain by proper care in twenty years.

REAGENTS.

In preparing specimens for the microscope it is necessary, in many instances, to keep the specimen surrounded by a fluid, as near as possible of the same nature as the fluid that bathes the tissues in the body. These fluids are called the normal fluids. They are:

1. Normal saline solution. It is prepared by dissolving 7.5 grammes of sodic chloride in 1000 c. c. of distilled water.

2. Blood-serum. Obtained by allowing some blood to clot in a flat vessel.

3. The aqueous humor of the eye.

4. Iodized-serum. A few crystals of iodine are dropped into fresh serum to preserve it; or, a quantity of amniotic fluid, obtained from an embryo calf, may be substituted for blood-serum. It is not highly recommended as a normal fluid.

Dissociating fluids are fluids which dissolve, or partly dissolve, certain parts of a tissue without affecting other parts, so that by shaking or teasing the unaffected portions can be isolated.

Iodized-serum, of a light brown color, is generally useful.

Chromic acid in weak solution, .02 per cent., is useful for isolating the nerve cells in the spinal cord.

Osmic acid, .1 to 1 per cent., solution, is a dissociating fluid of very general application.

Müller's fluid is useful for the stomach and kidney.

Sulphuric acid is used for isolating the cells of cornified epithelium, nails, etc. The tissue is placed in the acid for a few minutes when it is removed and washed in water to which a few drops of ammonia have been added.

Hydrochloric acid, 50 per cent. solution, is useful for isolating the uriniferous tubules of the kidney. The section of fresh kidney should be thin, and it should remain in the acid from ten to fourteen hours, when it is washed in alkaline water.

Caustic potash, 30 per cent. solution, is useful for the muscular and nervous tissues.

For softening bone, Dr. Seiler recommends the following:

Chromic acid, 1 grain.
Nitric acid, (C. P.) 2 C. C.
Water, 200 C. C.

In four or five days the bone will be soft enough to allow a fine

needle to pierce it. We have tried this mixture and are highly pleased with it.

HARDENING.

Hardening reagents act by coagulating the albumen and gelatine in the tissues and by abstracting water. Among the various reagents used for this purpose there are two of general use; alcohol and Müller's fluid.

As alcohol extracts the water from the tissue besides coagulating the albumen and gelatine, it is very liable to shrink the specimen. To obviate this shrinking as much as possible a small piece of tissue should be first placed in dilute alcohol and gradually transferred to stronger solutions until the absolute alcohol is reached, where it should remain until it is hard enough to cut.

Müller's fluid does not extract as much water as alcohol, but acts on the albumen and gelatine. It is prepared as follows:

Potassic bichromate, 2 parts. (or 2½ parts.)
Sodic sulphate, 1 part.
Water, 100 parts.

After this fluid has acted on the specimen for a few days it should be removed and a fresh quantity added.

At the end of two weeks the specimen is transferred to alcohol for a week or ten days, and then it is placed in absolute alcohol until the hardening process is complete.

Dr. Seiler uses a solution composed of equal parts of Müller's fluid, and 95 per cent. alcohol, claiming that large organs, as whole kidneys, brains, etc., may be hardened throughout in a comparatively short time.

The working microscopist will soon become familiar with a large number of other hardening reagents.

SECTION CUTTING.

But few specimens are in a suitable state in their natural condition to be submitted to an examination. They must be either teased or cut into thin sections.

If it be so desired, sections can be cut from fresh tissues with flat bladed scissors or with a Valentin's knife. For this purpose, however, the freezing microtome is generally employed. The specimen is placed in the well of the microtome and by means of

the ether or rigoline spray or by a mixture of ice and salt, it is frozen hard enough to cut.

When the material has been reduced to a fit condition for cutting by the action of alcohol or like reagents, it may be held in the left hand and thin sections cut with a razor held in the right hand. The razor or knife should be plane on one side and concave on the other, and when cutting, the concavity should be kept flooded with alcohol. Some experience is necessary in order to cut good off-hand sections, and if it be desirable that the sections compare well with each other in thinness, it will be necessary to employ a microtome as an aid, for without this aid a large number of the sections will be more or less imperfect. Before the specimen is placed in the well of the microtome it should be dipped in a solution of gum arabic, which is allowed to become nearly dry. Thus protected, the tissue is placed in the well close to that edge which will be nearest the knife when cutting and in such a position that the sections may be cut in the desired direction. The warm embedding mixture is poured over and around the tissue until the well is filled. The microtome is now removed to a cool place when the mixture soon hardens. The following are recommended as embedding mixtures:

Solid paraffin, 3 parts.
Cocoa butter, 1 part. } SOFT.
Hog's lard, 3 parts.

Solid paraffin, 2 parts.
Cocoa butter, 1 part. } HARDER.
Spermaceti, 1 part.

Solid paraffin, 3 parts.
Cocoa butter, 2 parts. } HARD.
Spermaceti, 1 part.

Paraffin, 2 parts. } TRANSPARENT AND
Vaseline, 1 part. } EASY TO CUT.

STAINING.

After the sections have been cut it will be necessary to stain them in order to differentiate their several parts. The following are a few formulæ in general use:

BEALE'S CARMINE.

Carmine, 10 grains.
Strong liquor ammoniæ, ½ drachm.
Glycerine, 2 ounces.
Distilled water, 2 ounces.
Alcohol, ½ ounce.

The carmine, in small fragments, is placed in a test-tube, and the ammonia added to it. By agitation and by the aid of heat, the carmine is dissolved. The ammoniacal solution is boiled a few seconds, and then allowed to cool. After the lapse of an hour, much of the excess of ammonia will have escaped. The glycerine and the water are added, and the whole passed through a filter, and allowed to stand for some time, when the clear supernatant fluid is poured off and kept for use.

Woodward's carmine, modified from Tiersch, is prepared as follows:

Best carmine, 15 grains.
Borax, 1 drachm.
Water, 5½ ounces.
Alcohol (95 p. c.), 11 ounces.

Mix and filter. The filtrate should be thrown away. On the filter will remain the crystals. The filter, with the crystals, is placed in a mortar and thoroughly mixed with 8 ounces of water. This solution is filtered, and the filtrate evaporated to 4 ounces, when it is ready for use. After the section is stained a lilac color, taking from 30 seconds to one minute, it is placed in a fixing solution composed of—

Hydrochloric acid, 1 part.
Alcohol (95 p. c.), 4 parts.

Here it is allowed to remain until the lilac color changes to a rose red.

Hæmatoxylin. Make a saturated solution of crystallized calcic chloride in 70 p. c. of alcohol. Shake and let it stand. Add alum to excess. Shake well, let it stand, and then filter. Make a saturated solution of alum in 70 p. c. alcohol. Add this to the above filtrate in the proportion of 8 to 1. To this mixture add, drop by drop, a saturated solution of haematoxylin in absolute alcohol, until

the mixture has a dark purple color. An excess of this staining can be removed with dilute acetic acid.

Aniline blue-black. Dissolve five grains of aniline blue-black in 100 c. c. of water. Dilute with water to any strength required.

Sulphindigotate of soda, osmic acid, eosin, nitrate of silver, and the various aniline colors, all have their general and special uses.

The difficulty of preparing these staining reagents is such that it is the wisest economy to purchase them, already prepared, from some responsible dealer.

MOUNTING.

There is no substance more generally used for mounting purposes than Canada balsam. It is used also in solution with benzole

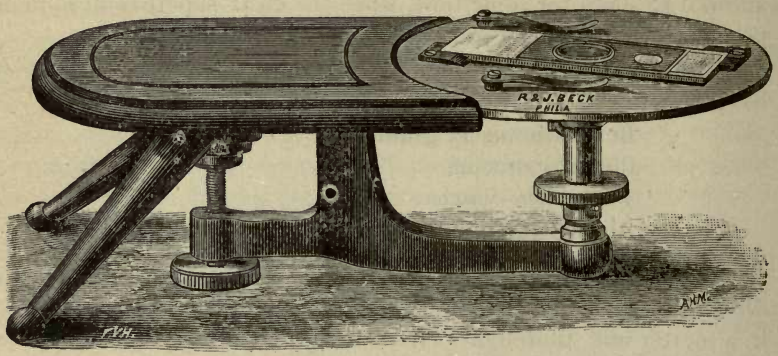


Fig. 6. Turn-Table. (*R. & J. Beck.*)

or alcohol. To prepare it in this way, a clear sample of the balsam is taken and evaporated in a water bath until all odor of turpentine has disappeared. This balsam will be hard and brittle when cold. The hard balsam is warmed, and enough benzole or absolute alcohol added to dissolve the balsam, and make the solution, when cold, of the consistence of thin syrup. To mount sections in this medium, it is necessary to remove all water from them by transferring to alcohol, and from that to absolute alcohol. The alcohol is then removed, and the oil of cloves added. When transparent the oil is removed, and the sections are now ready for mounting. In a few weeks the mounts will become dry; this drying may be hastened, of course, by keeping the specimens exposed to an elevated temperature.

If it is desirable to mount the section in some watery medium, it will be necessary to make a ring or cell upon the slide. The cell may be made with white zinc, Brunswick black, or gold size. The slide is placed upon a turn-table, and with a sable brush a cell is made a trifle smaller than the diameter of the cover, so that the edge of the cover is in the center of the ring of cement. A number of these cells can be kept on hand, and when one is wanted for use, it is only necessary to apply a little fresh cement to the outer half of the ring, in order that the cover may adhere to it at once. After the specimen has been placed in the cell with the mounting fluid—in which the specimen has rested for some time—and the cover applied, another ring is spun around the edge of the cover in order to seal up the cell. The various methods of making cells cannot be discussed here. They are all useful, and many of them beautiful. Deep cells can be made by using rings of glass, or of wax, or, as Mr. Griffith has suggested, of curtain rings. The details for this work must be sought for either in works devoted exclusively to mounting, or in the various microscopical journals published at home and abroad.

INJECTING.

It is impossible to describe the art of making satisfactory injections. Anything approaching perfection is attained only after long practice and careful attention to the many minute particulars. A small brass syringe, supplied with a stopcock and several nozzles of different sizes, answers every purpose; or an injecting apparatus may be made as represented in figure 7. A, represents a pail partly filled with water, which can be raised or lowered, to regulate the pressure, by fastening one end of a cord to the handle of the pail, and then passing the other end over a pulley fastened to the ceiling of the room; b is a bottle with an air-tight fitting cork, pierced by two short glass tubes; c is a bottle partly filled with the injecting fluid. Through the cork of this bottle are two glass tubes, one of which is short, while the other reaches nearly to the bottom of the bottle; d is a brass nozzle with a stopcock; r is rubber tubing, which unites the different parts as seen in the figure. A Y-shaped glass tube can be inserted midway in the rubber tube between the two bottles, so that two bottles of the injecting mixture can be attached to the one

large bottle b, which is empty at first. A third glass tube can be placed in the cork of the bottle c, which can be united by rubber to a U shaped glass tube partly filled with mercury, and thus the amount of pressure obtained. By raising the pail the water descends the rubber tubing and compresses the air in the bottle b. The air is forced through the middle piece of rubber tub-

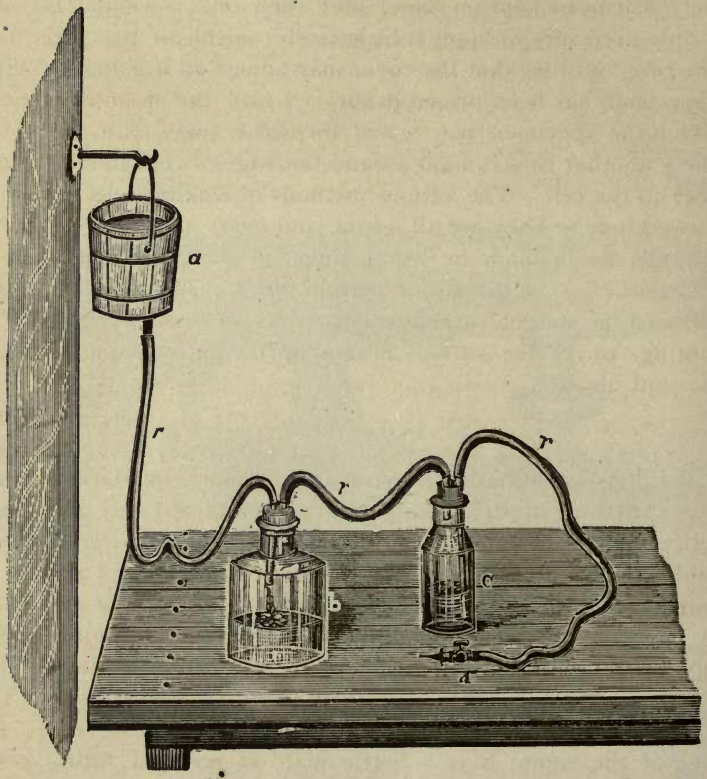


Fig. 7. Injecting Apparatus.

ing and presses on the top of the injecting mixture in the bottle c. The injecting mixture is thus forced up the long glass tube, along the rubber tube to the canula, and through it into the organ or animal to be injected. A slow and steady pressure is obtained in this way, which we have found exceedingly desirably in many cases.

The most perfect and most beautiful injections we have ever made have resulted from the use of "Seiler's carmine gelatine." It

can be purchased of any dealer in microscopical accessories for one dollar an ounce. One ounce of this gelatine is dissolved in ten ounces of water, and the mixture injected into the vessels while it and the organ to be injected are both hot. Dr. Seiler prepares the gelatine as follows:

Take of

Best carmine, 2 drachms.
Distilled water, 3 ounces.
Strong liquor ammonia, 20 drops.

Dissolve this and filter through cotton, covering the funnel with a piece of glass plate, to prevent the evaporation of the ammonia. The filtration is a somewhat tedious process, but is absolutely necessary; the solution, however, will keep, and may therefore be kept in stock.

Then take of—

Cox's gelatine, 2 drachms.
Distilled water, 2 ounces.

Soak the gelatine in the water until it becomes soft, and then dissolve it in a water bath and strain through fine flannel while hot. Heat the gelatine solution again and add the carmine solution, and bring the temperature up to about two hundred degrees, Fahrenheit. Dilute acetic acid must then be added, drop by drop, under constant stirring of the mixture, until the ammonia is just neutralized, which is indicated by a sudden change of color in the solution, from a lilac to scarlet.

Dr. Seiler describes this process very minutely, and yet, in our estimation, it is wiser economy for the busy worker to purchase it rather than to make it.

For a blue injecting mixture we have had the best success with Beale's Prussian blue. In fact, could we be assured of a perfect mixture, we should regard it as superior to the carmine gelatine. It penetrates the finest capillaries, and, if properly prepared, shows no fine granules under the microscope.

It is made as follows:

Best glycerine, 2 ounces, by measure.
Muriated tincture of iron, 10 drops.
Ferrocyanide of potassium, 3 grains.
Strong hydrochloric acid, 3 drops.
Water, 1 ounce.

Mix the tincture of iron with one ounce of the glycerine, and the ferrocyanide of potassium, first dissolved in a little water, with the other ounce. Mix these solutions together gradually, under constant shaking. The iron solution must be added to the ferrocyanide of potassium. Lastly, the water and acid are added, drop by drop, under constant shaking.

BLOOD.

IF a drop of blood should be placed on the slide, covered with the thin glass and transferred to the microscope, the examination would be anything but satisfactory. The number of corpuscles in the field would be so great and the number of layers so many that the specimen could not be studied to advantage. Again, if mixtures be used to dilute the blood, unless prepared with the greatest care, the corpuscles will be materially changed in appearance.

When a comparatively short examination is required, the following method will prove satisfactory: To procure the drop of blood, one of the fingers is congested by tying around its base a string or handkerchief; when well filled with blood, a fine cambric needle is thrust quickly through the skin over the end of the congested finger; one surface of a glass slide is now gently breathed upon, and this slightly moistened surface brought in contact with a drop of blood, just pressed from the puncture; one surface of the cover-glass is also breathed upon and its edge placed close to, just in contact with the edge of the drop of blood, and with the aid of a needle the cover is lowered away from the drop—not over it—until it comes in contact with the slide; the blood-corpuscles will readily flow between these moist glasses, by capillary attraction, until the surface beneath the cover-glass is nearly or entirely covered; prepared in this way, there is but one layer of corpuscles and the whole specimen shows to the best possible advantage.

For this method to be successful it should be carried out rapidly and the moisture should not be in excess, as water causes changes in the corpuscles; yet it should be sufficient to allow the corpuscles to flow readily under the cover. The amount is soon learned after one or two trials. If the examination is to continue for some time a layer of oil can be placed around the cover-glass to prevent the drying of the specimen.

Examined with a magnifying power of about four hundred diameters one never fails—when the specimen is prepared as described above—to see beautiful and perfect representations of the rouleaux.

Nearly all the red corpuscles are seen adhering to each other by their flat sides. The rouleaux can be broken and the corpuscles separated from each other by gently tapping the edge of the cover-glass. Not all the red corpuscles necessarily enter into the rouleaux, yet the white never do, therefore when examining a specimen of blood, showing the rouleaux, a few corpuscles will be seen alone, larger in size than the mass of corpuscles, globular and granular,

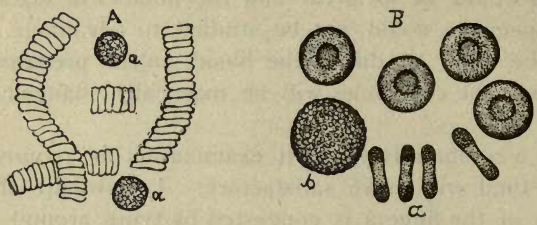


Fig. 8.

A, human blood in rouleaux. a, white corpuscles. x 400. B, human red blood corpuscles. a, seen on edge. b, white corpuscle. x 1000.

these will be the white corpuscles, or leucocytes. The beginner is frequently troubled to find the white corpuscles of the blood. He should, first, become familiar with the appearance of these bodies by studying them apart from the red corpuscles. This can be done very easily, in a specimen prepared as above, by placing a drop of water to one edge of the cover and a strip of blotting paper at the opposite edge. In this manner all the red corpuscles can be washed away while the white will remain.

Another method is this, while looking at the red corpuscles they are thrown slightly out of focus by the fine abjustment. If any white corpuscles are in the field they will appear as bright dots; fixing the eye on one of these bright dots the red corpuscles are refocused when the bright spots appear as white corpuscles.

Besides the plan described above for obtaining a thin layer of blood the following may be tried: Draw the end of a smooth, ground glass slide through the drop of the blood on the end of the

finger, press the end of this slide against the flat surface of another slide, and draw it quickly across the same, holding the two slides perpendicular to eachother.

The end of the first slide should be placed a little to the right or left of the centre of the other slide, in order that the middle of the film of blood may be on the middle of the slide. The cover is applied at once and the specimen examined.

If it be desirable to preserve the specimen, then proceed as just described only do not apply the cover. Then examine the specimen and if found suitable a ring of the white zinc is placed around the most desirable portion. The slide is now gently heated in order to dry the air that is in the cell. The cover is then applied and another ring of the white zinc added.

The red corpuscles appear as circular, flattened, biconcave discs with rounded edges. When seen on the side the centre appears either light or dark, depending upon the focus. Acting as a biconcave lens, when the object is slightly within the focus, the centre will appear light, when without the focus dark. The red corpuscles of all the mammalia are of this shape, with one exception, the camelidæ, in which they are oval.

The red-corpuscles have a light amber or yellowish-green color; they are red only when seen in masses.

The size of the red corpuscle varies, not only in the same individual at different times, but also in the same drop of blood examined at any one time. The size usually give is from $\frac{1}{3333}$ to $\frac{1}{3500}$ of an inch.

The following is a list of measurements of the red corpuscles of some of the different animals, as gived by Gulliver:

Man,	1–3200
Dog,	1–3542
Cat,	1–4404
Hog,	1–4230
Horse,	1–4600
Sheep,	1–6355
Ox,	1–4267
Musk-deer,	1–12325

(For full table see Sydenham edition of Hewson's works, p. 237, or consult some of the standard works on physiology). The point that is

of interest in this connection is; what is the value of these corpuscles in medico-legal cases? That is, by a microscopical examination of a blood-vessel or clot, either fresh or otherwise, can human blood be told from the blood of the lower animals? This must be considered a very easy matter in some cases. Take, for instance, the red blood corpuscles of all the birds, reptiles, amphibia, and fishes; here the corpuscles are large, oval bodies, with a large, round or oval nucleus. (The red corpuscles from the family of the lampreys are circular, but the nucleus is prominent.) If, then, the question arises, "Is this human blood," and an examination shows the red corpuscles as oval, nucleated bodies, the answer can positively be given, "No." If, however, the corpuscles are circular in shape, having no visible nucleus, then an entirely different problem is involved. Here the question is one of size, and not of shape, and it must be decided by measurement. First of all, there must be fixed, if possible, a standard size to the human red corpuscle; for the size of the corpuscles of many of the lower animals is so nearly the same that the figures in each case should give a fixed average size.

Has the red blood-corpuscle of man a fixed size? It appears not; in fact, by consulting the various authorities, we cannot arrive at a fixed average size. In examining a drop of blood with high powers, one very frequently finds a few minute colored corpuscles below the 1-4800 of an inch in diameter. Some few may be found as large as the 1-2600 of an inch in diameter. These few, very small and very large, corpuscles are not included in making up the average size; they are easily excluded, and only the most perfect and most common corpuscles are measured. Yet notice what the various authorities say:

Diameter of the human red blood-corpuscle as given by

Gulliver, 1–3200 of an inch.
Flint, 1–3500 of an inch.
Dalton, 1–3531 to 1–3050 of an inch.
Woodward, 1–3092 of an inch.
Frey, 1–2840 to 1–4630 of an inch.
Welcker, 1–3230 of an inch.

Our own observations give 1–3367 of an inch.

Thus it cannot be said that there is any fixed average size to this corpuscle, each investigator having an average size of his own.

Schmidt says that over 90 per cent. of the red corpuscles found in a single specimen are of the same dimensions. This much, however, can be said; that, after measuring a large number of corpuscles if their average diameter be found either the 1–3500 or 1–3200 of an inch, or any fractional part between these two, the blood may be that of man. It need not necessarily be that of man, for all authorities agree that the blood of the monkeys, baboons, etc., beaver, porcupine, guinea-pig, and a few other animals have corpuscles identical with those of man. Yet only the blood from certain of the more common inferior animals would be liable to enter a medico-legal contest. We refer especially to the dog, cat, hog, horse, sheep and ox.

Before considering these cases, this significant fact should be borne in mind; the blood of these animals has not been studied with anything like the care and time bestowed upon human blood. It follows, then, that if the blood of these animals should be studied as carefully, we would find as great a variation in the size of their red corpuscles as exists in man; further, there would be as great a variation from the size given by Gulliver as is true in the case of man. As each investigator gives a particular size to the human red corpuscles, all varying from that given by Gulliver; so, we have every reason to believe, would each investigator give his particular size to the red corpuscles of the lower animals, all varying from Gulliver.

Can the blood of the dog be told from that of man? From the table of Gulliver we learn that there is a difference,—such a difference as exists between the 1–3200 and the 1–3500 of an inch. Woodward, however, has completely settled this question. He says, "The average of all the measurements of human blood I have made, is rather larger than the average of all the measurments of dog's blood. But, it is also true that it is not rare to find specimens of dog's blood in which the corpuscles range so large that their average size is larger than that of many samples of human blood." The mean average of corpuscles in 22 drops of human blood (1766 corpuscles) ranged from .000,309 to .000,343 of an English inch. Nearly the same number of corpuscles of dog's blood gave .000,-396 to .000,340 of an inch. *Monthly Microscopical Journal*, 1876, p. 132.

No other conclusion can be reached than that the red corpuscles of the blood of man and the dog are the same in size.

In the case of the five animals, the cat, hog, horse, sheep and ox; the corpuscles of the ox and hog are the nearest in size to those of man; hence if we can tell the blood of these animals from that of man, we shall be able to tell, even more readily, the blood of the cat, horse and sheep.

Can the blood of the ox and hog be told from that of man, even when dried or in clots? We believe that a positive distinction is possible, not only in freshly prepared specimens, but also when the specimens have been placed under very unfavorable conditions, as when the blood has been dried upon clothing or pieces of wood, etc. Still the very best of aids should be at the manipulators command. Very high magnifying powers should be used, from three to five thousand diameters, requiring a 1-25 or 1-30 or 1-50 objective. A very accurate cob-web eye-piece micrometer has proved indispensable in our hands. The value of the spaces on the milled head should be ascertained by using a stage micrometer known to be accurately ruled. Again, a large number of corpuscles should be measured and their mean average taken. In no part of the general or special work of the microscopist are attention to detail, great care, judgment and skill in such demand. What then shall we say of those who show such a reckless ambition in this particular line?

If, then, the question be asked us—is this the blood of man as distinguished from the blood of all other animals? We should be forced to reply,—it is impossible to tell. If, however, the question is to decide between the blood of man and one of the inferior animals, many times a positive answer could be given.

Between the blood of man and his most constant companion, the dog, there appears to be no difference; while it is possible to tell the difference between the blood of man and the blood of the sheep, cat, horse, hog and ox.

There is some discussion concerning the best method of examining a specimen of dried blood. We believe the following method will give as good results as any: Some of the dried blood is scraped from the surface to which it is attached, and the dry clot placed on a slide and covered with a thin glass. If the operator should not have thin enough glass to use with his 1-30 or 1-50 he can use, for the time, a thin scale of mica. A drop of saline solution (three-

fourths of an one per cent. solution) is placed to the edge of the cover and allowed to run under and moisten the specimen. The specimen is examined now with the highest power at command. If the particles of clot are so deeply colored that the corpuscles are indistinct, then the color may be washed out by placing some of the salt solution at one edge of the cover and a piece of blotting paper at the opposite edge. Care should be used not to move the cover-glass during the operation. If found desirable, all the color can be removed from the clot in this way. Try again to see the corpuscles sufficiently well to be able to measure them. If they are too pale they may be colored. Sometimes a drop of iodized serum will suffice, added cautiously to the edge of the cover. Weak solutions of iodine have proved the best of anything for this purpose in our hands. We do not believe this coloring changes the diameter of the corpuscles in the least. Those corpuscles most perfect in shape should be chosen for measurement.

Persons have testified, as experts, in criminal cases, and have accurately described their methods and measurements of corpuscles, and have actually sworn that the stain they examined was composed of human blood, when upon closer examination in the hands of genuine experts the corpuscles were proved to be vegetable spores. There is scarcely a microscopist in this country that does not remember the details of the case to which we refer. Let it be remembered that potassic hydrate and glacial acetic acid will completely destroy the blood corpuscles in a short time, but will not materially affect the spores of the vegetable kingdom.

We are not able to give any positive distinctions between the blood-crystals of the various animals sufficient to make them of value in criminal cases.

The blood of most of the mammalia, including man, generally yields prismatic or rhomboidal crystals. The blood of the guinea-pig crystallizes very easily, giving beautiful tetrahedral crystals. In the squirrel the crystals are hexagonal tables. To obtain hæmin crystals, a drop of blood is placed in a watch crystal and about twenty times its bulk of glacial acetic acid added. The mixture is then warmed, and as it evaporates the desired crystals will be formed; or, to a drop of dried human blood add a few crystals of common salt, cover with a thin glass and place a drop of glacial acetic acid to its edge, allowing it to run under and come in contact

with the blood. The specimen is then carefully warmed, and soon the reddish-brown hæmin crystals appear. To obtain a larger number of cystals, a quantity of blood is boiled for one or two minutes in twenty times its bulk of glacial acetic acid and immediately filtered. As the filtrate cools the cystals will be deposited. To obtain crystals of hæmoglobin, a drop of the blood of a rat is mixed with two drops of water and allowed to evaporate slowly.

CHANGES IN BLOOD.

In 1881 Manassein made an extended series of observations upon the changes which the red corpuscles undergo under various circumstances. He made over 40,000 measurements of the corpuscles from 174 animals. The following results were obtained: A reduction in the size of the red corpuscles was caused by septicæmic poisoning and probably traumatic fever, by an increase in the bodily temperature, and by remaining a short time in a space surchanged with carbonic acid gas. An increase in their size was caused by a reduction of the bodily temperature, by medium and large doses of muriate of quinia, by cold, hydrocyanic acid in fatal and non-fatal doses, muriate of morphia, oxygen, acute anæmia (after arteriotomy), and by alcohol in intoxicating doses.

Laschkewitsch found that the red corpuscles, in Addison's disease, were larger, paler and altered in shape. Törueroth, Ilmoni and others have reported the red corpuscles as wrinkled, crenated, and shrunken in typhus and tabes. The same has been observed in Asiatic cholera, attributed to the reduction of serum. It has been reported that in the various peurperal disorders the rouleaux of the red corpuscles is absent.

EXCESS OF WHITE CORPUSCLES.

We believe that this condition was first noticed by Professor Virchow, in 1845. At that time he made a careful examination of the body of a person whose death was not satisfactorily explained. He found an enlarged liver and an enormous excess of white corpuscles.

By preparing the blood in the usual way, and examining it with a power of about 400 diameters, any great excess of the white corpuscles will be apparent, especially to one familiar with the appearance of normal blood. This increase may be so great as to cause one white to two red, in which case it will appear that the white

outnumber the red, owing to their larger size. The excess appears very marked, however, if there is one white to ten red.

OTHER ELEMENTS IN BLOOD.

Small elements have been found in the blood varying from 1-6000 to 1-8000 of an inch in diameter, having a bright, shining look, and the same color as the red corpuscles. Observers, who have described these bodies, call the disease under which they are found microcythemia. These elements may be identical with the syphilitic corpuscles of Lostorfer.

A few cases have been reported where filariæ have been found in the blood. Notably the cases described by Beale in the fourth edition of *The Microscope in Medicine*, p. 480. Also in the *Queckett Journal of Microscopy* for July, 1881.

They are found quite frequently in the blood of the Chinese, at least when in their native country. The persons may, apparently, enjoy good health at the time. A mysterious phenomenon is connected with the periodicity of these organisms. One writer says that between four and six in the afternoon the filariæ begin to appear and they increase until midnight, then diminish until nine or ten in the morning, when they have entirely disappeared. This periodicity appears quite independent of the habits of the patient.

To ascertain the globular richness of the blood the corpuscles must be counted in a known quantity.

It is necessary, first, to select a proper diluting fluid. Dr. Frederick P. Henry, of Philadelphia, has given this subject a great deal of attention, and he prefers a solution of sulpho-carbolate of soda, although the borax-urine solution of Keyes' is highly recommended.

Dr. Henry prefers the Hayem and Nachet instrument, diluting the blood one to two hundred and fifty.

Should any of our readers desire to investigate this subject, they can get great help from a perusal of the Cartwright Prize Essay for 1881, published by F. A. Davis, and written by Dr. Henry, both of Philadelphia.

Virchow, Meckel, Donders, Vogel and Von Duben have reported the presence of cells in the blood. The cells were supposed to be the epithelium from the walls of the vessels. But little is known on this subject and the cases described have been found in the blood

by such observers as Virchow, Queckett, Paget, and others. Their presence would be accidental and they would only corroborate a diagnosis that must be clear at such a time in the advanced stage of the disease.

In examining blood it is well to remember that water causes the red corpuscles to become spherical, dissolving out the coloring matter, and later, causes their total disintegration. Normal saline solution gives them the crenate or horse-chestnut form. Tannic acid, in a two per cent. solution, causes the hæmoglobin to collect at the periphery in the form of one or more round masses.

EPITHELIUM, CONTENTS OF ORAL CAVITY, SPUTA, VOMITED MATTERS, FÆCAL MATTER, MILK.

THE general distribution of epithelial cells and the great variety in their size and shape, render their careful study a necessity.

The microscopist is liable to find these cells when examining almost any tissue.

The surface of the body is covered with a stratified layer of epithelium, consisting of irregular, broken cells, without nuclei.

The cells composing the nails are irregular in shape, enclosing a round or lens-shaped nucleus. They can only be demonstrated by the aid of reagents, as by boiling in a 10 per cent. solution of soda.

CONTENTS OF ORAL CAVITY.

The epithelium lining the oral cavity is of the pavement or flattened variety. The cells are of large size, from 1–450 to 1–750 of an inch. They have usually a single nucleus, with granules deposited in the formed part. Besides these cells, the saliva will contain a number of globular bodies, containing one or two nuclei, and averaging about the 1–2500 of an inch in diameter. They are the so-called salivary corpuscles. Normally, then, the saliva contains only these two kinds of cells; however, in examining the contents of the oral cavity there are almost invariably found a number of minute hair-like bodies, consisting of filaments of one of the algæ, *leptothrix buccalis*. These filaments are attached to, and grow upon the cells of epithelium situated toward the back of the tongue. They are found also between the teeth and in the tartar. Aside from these filaments, it is quite common to find in the mouth fragments of food, infusoria, starch granules and fat. The coatings of the tongue appear to be composed of epithelial cells and mucus,

and the various colors seem to be due, in some cases at least, to the presence of the coloring matter of the blood. The microscope will be of great value in diagnosing the peculiar disease of the mouth, known as aphthæ. This chiefly occurs in infants but may extend to adults who have suffered from long-exhausting disease. Aphthæ was first correctly described by Gruby, of Vienna, in 1842,

Fig. 9. Saliva. a, epithelial cells. b, salivary corpuscles. x400.

and was shown by him to be due to a vegetable parasite which is distributed between the epithelial cells covering the lips, cheeks, gums, tongue, pharynx and œsophagus, and according to Robin sometimes the stomach, small intestines and rectum. The fungus is classed by Robin under the genus *oidium* and called by him *oidium albicans.*

The spores of this fungus are round, oval, and irregular in shape, sometimes nucleated, and varying from the 1–1500 to the 1–12000 of an inch in diameter. They are seen either floating free or grouped together closely connected with the epithelium. Besides the spores there are tubular, articulated filaments in which are exceedingly fine granules, which are sometimes seen in motion. To examine for these spores some of the whitish matter is placed upon a slide and a drop of potash solution added to make the cells and mucus transparent; the whole is now covered with the thin glass and examined under a power of from 400 to 750 diameters.

SPUTA.

All the normal and pathological ingredients of the oral cavity may be found when examining the sputa for the purpose of

determining the condition of the respiratory passages. The microscopist must be more or less familiar with all their various appearances or ludicrous mistakes will be liable to occur. If, however, the three following suggestions be carefully carried out the necessary difficulties will be greatly overcome. First, during the collection of the sputa, the patient should rinse and brush the mouth thoroughly after each meal, using a stiff brush and taking pains to remove all particles from between the teeth. Second, the dish, in which the sputa are to be received, should be very clean. Third, if the patient places tobacco in the mouth he should be denied his luxury at this time, for particles of vegetable leaf may mislead the observer. If the amount of sputa be small, then all raised during the twenty-four hours should be saved. If large, that first raised in the morning should be preferred. Any little grayish masses should be chosen and placed at once under the microscope. Acetic acid will clear up the mucus, etc., and render more distinct the yellow fibres if they should be present. If this examination reveals nothing, the following method should be adopted:

Make a solution of sodic hydrate, 20 grains to the ounce of water. Mix the sputa with an equal bulk of this solution, and boil. Then add to this mixture four or five times its bulk of cold water. Pour into a conical-shaped glass and set aside. Soon the yellow fibres, if present, will fall to the bottom; from here they can be drawn up with a pipette and examined. Several glass slides should be examined at a single sitting, and the examination should be repeated every few days until the presence or absence of these fibres is satisfactorily demonstrated. If these fibres are not found it does not by any means prove that serious trouble may not exist, but if these yellow elastic fibres—fragments of lung tissue—are found, it proves that there must be a disintegration of the pulmonary tissue, a condition which must denote serious trouble. In 1878 Sokolowski and Grieff made a report on the value of elastic fibres in the sputa. Their report is based upon an examination of seventy patients. The examinations were made by two methods,—fresh and by Fenwick's method. Usually they mixed the sputa with a solution of soda,—liquor sodæ, 1 part, distilled water, 2 parts—and boiled it for four or five minutes, then diluted it with an equal quantity of distilled water, and fished out and examined the particles suspended in the water. Of the 70 patients, 19 had breaking down of lung sub-

stance with hectic; in 18 of these cases they found the elastic fibres. In one case the absence of fibres corresponded with temporary improvement. Of 11 cases of chronic phthisis, with unmistakable

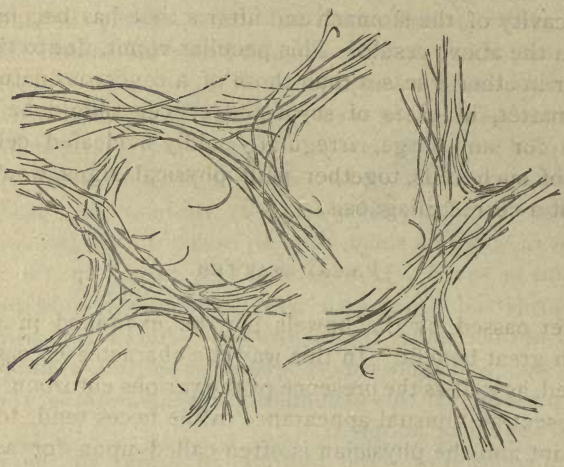


Fig. 10. Fragments of lung tissue (yellow elastic fibres.) Sputa from case of phthisis. Mucus, pus, epithelium, granular matter, etc., were in great abundance. x215.

signs of lung destruction, elastic fibres were found in all. In 75 per cent. of cases of consolidation they found the elastic fibres present, which shows, they say, how frequently destruction is going on although the physical signs are those of consolidation only. In one-third of the cases of slight consolidation elastic fibres were found. In many cases, then, in spite of seeming temporary improvement, the microscope will decide that destructive changes are still going on.

The rusty color of the sputa of pneumonia is due to the presence of escaped red blood-corpuscles, and as their escape is gradual they become thoroughly mingled with the exudate.

VOMITED MATTERS.

The examination of vomited matter requires no special directions. The great variety of material met with in the vomicæ renders it necessary that the examiner be familiar with the general microscopic character of nearly all the tissues, animal and vegetable.

Vomited matter is usually examined to ascertain the nature of some serious affection of the stomach, usually suspected cancer. The "coffee-ground vomit" appears to be due to the presence of the coloring matter of the blood. The blood has gradually escaped into the cavity of the stomach and after a time has become broken down with the above result. This peculiar vomit, due to this cause, may occur in other diseases than those of a cancerous nature. The vomited matter, in cases of suspected cancer, should be carefully examined for any large, irregular, boldly nucleated cells. The presence of such cells, together with physical signs, would aid in arriving at a correct diagnosis.

FÆCAL MATTER.

Matter passed by the bowels may be examined in particular cases with great benefit. In this way the character of casts can be determined, as well as the presence of the various entozoon. Objects which present an unusual appearance in the fæces tend to frighten the ignorant and the physician is often called upon for an opinion in such cases.

As a sample we recall the following:

A patient called in great trouble of mind over her distressed condition. "The mucous membrane of the whole alimentary canal was gradually passing off." Home remedies had been tried for a number of days without effect, in fact the disease was on the increase.

The person was exceedingly nervous and greatly agitated over her "deplorable condition." We obtained some of the "mucous membrane" and brought the microscope to our aid. The membrane was resolved into the beautiful spiral vessels of the vegetable kingdom. A close questioning revealed the fact that celery had formed a large part of the diet for a number of days, and the more the patient worried so much the more celery was eaten "to quiet the nerves." Fragments of tobacco leaf have been the cause of alarm, "looking like long, slender worms." Von Duben relates how fragments of linen, imbedded in the mucus and feces, were mistaken for intestinal worms. Again, how a number of small, white, equally wide pieces of cellular tissue from meat-balls looked like links of tapeworm.

Prof. Buhl reports a case where the mucus had undergone such changes, that to the unaided eye, it simulated tapeworm.

Dr. Bennett, in his "clinical lectures," reports the following: A child was supposed to be affected with worms, because it passed yellow shreds in abundance, which to the naked eye closely resembled ascarides. All kinds of vermifuge remedies had been tried in vain. On examining the shreds with a microscope, he found them to consist of the undigested spiral vessels of plants; and they ceased to appear when the vegetable broth, used as food, was abandoned.

He reports this also: An individual was supposed to be laboring under dysentery from the frequent passages of the yellow pulpy masses in the stools, accompanied with tormina and other symptoms. On examining these masses under the microscope, he found them to consist of undigested potato skins. On inquiry it was ascertained that this person had eaten the skin with the potatoes. On causing them to be removed before dinner, the alarming appearance ceased, and the other symptoms also disappeared.

We have found a number of larvæ in the fæces; they were from three-eighths to one-half inch in length, but were dead when examined.

There is conclusive evidence that maggots, larvæ, etc., will pass through the whole length of the alimentary canal in a living state Cheese mites, insects and fragments of insects may be discovered.

MILK.

The examination of milk is without difficulty. A drop of the fluid is placed on a slide, the cover-glass applied, and the specimen examined with a power of about 400 diameters. The "milk globules," or oil globules, vary from the 1-2500 to the 1-2000 of an inch in diameter. They do not have, as a rule, a perfectly regular outline. They do not run together to make large globules, neither will the addition of ether effect their solution. Each globule is surrounded by a thin covering, which must be destroyed before the ether will act. Strong acetic acid will dissolve the covering, and so will several of the alkalies. If the milk be examined shortly after delivery, it will be found to contain large, spherical bodies, consisting of a collection of oil globules embedded in some soft material. These are the colostrum corpuscles. Occurring normally after

delivery, their presence is of value many times in a forensic point of view. When milk is added to other fluids for purpose of imposition, it can be detected by the presence of the milk globules, and by the precipitation of the casein by acetic acid. Flour, chalk, etc., are easily detected when used as adulterations.

Fungi rapidly develop in milk as soon as it commences to change, and a drop is seen to contain myriads of bacteria in a few hours after its removal from the living animal. The microscope will show, many times, countless numbers of bacteria in the clotted milk vomited by the infant. Thus the whole alimentary canal might become filled with undigested milk swarming with bacteria, causing irritation, and perhaps serious illness.

MUSCLE.

The examination of muscle for trichinæ is very simple. Small shreds of the muscle should be teased with needles in some normal fluid medium, and examined at once with a low power; one giving 50 diameters will be sufficient at first, although for a more careful examination one of 250 or 300 diameters should be employed. Thin sections can be made with a razor through the trichinous muscle hardened in alcohol, using the proper care that the sections be made in the direction of the fibres. The worms are seen coiled up as in figure 11.

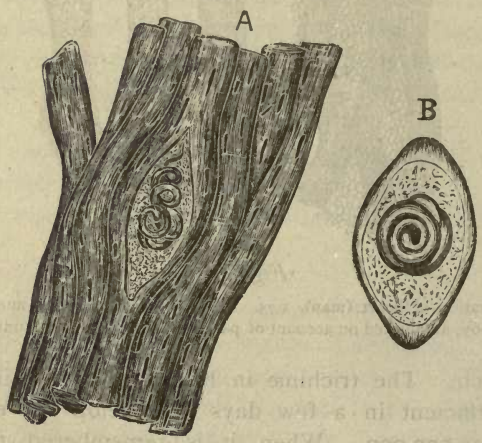


Fig. 11. Trichinous Muscle.

A, from psoas muscle of hog. B, encysted trichina from arm of man. B, x 35.

They may be found in any of the transversely striated muscles with the exception of the heart. They are most frequently found, however, in the diaphragm and muscles of the jaw and neck. They are in greatest abundance at the tendinous extremities of the muscles, for they are here prevented

from moving farther. In the hog, fragments of muscle should be examined especially from the ham and tenderloin. They are usually found arranged spirally just beneath the sarcolemma. This spiral arrangement gives them their specific name, trichina spiralis. They were discovered in January, 1860, by Professor Zenker of Dresden. In 1864 Professor Dalton counted the number of trichinæ in a piece of muscle $\frac{1}{12}$ of an inch square and $\frac{1}{50}$ of an inch thick, and found 12. This would give about 85,000 to the cubic inch. In another specimen of the same size he found 29 trichinæ, giving again in round numbers 208,000 to

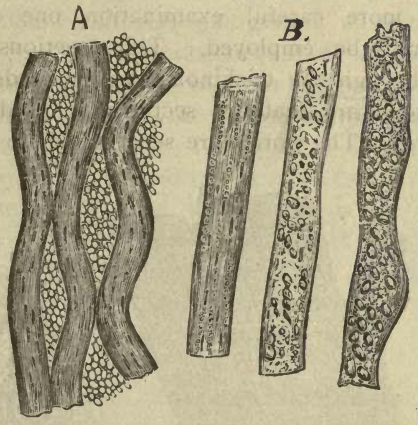


Fig. 12.

A, fatty infiltration of heart (man). x 75. B, fatty degeneration of muscle from arm of boy, amputated on account of paralysis of three years standing.

the cubic inch. The trichinæ in half a pound of infested meat would be sufficient in a few days to develop the extraordinary number of 30,000,000. When it is remembered that each of these worms must puncture the mucous membrane in its way to the muscles, it is readily understood why they should occasion such notable disturbance. As found in muscles they are usually surrounded by a cyst containing granules or calcareous matter. In size they average about $\frac{1}{30}$ of an inch in length and $\frac{1}{600}$ of an inch in thickness. They retain their vitality in the encysted state for a great length of time.

Muscle sometimes becomes streaked with fat when it can

be examined either fresh or after being treated with Müller's fluid or chromic acid. When the fat is confined to the connective tissue between the muscle fibres as in obesity, nothing serious can result from it, unless in some particular organs when it may cause a dilatation and weakening from pressure. A specimen of fatty infiltration is seen at figure 12.

When the fat molecules are arranged in rows corresponding to the longitudinal striæ, they usually increase in number until all the contractile substance disappears and the muscle fibre becomes transformed into a row of fat cells, the fatty degeneration causing a complete wasting of the muscle. Non-striated muscle cells undergoing this fatty metamorphosis are found in the uterus a few weeks after delivery, when in order for this organ to become reduced to its previous size many of the cells become thus broken down and carried out of the body.

URINARY DEPOSITS.

In examining a specimen of urine it is desirable to have the whole quantity passed in the twenty-four hours. If, however, the presence or absence of any particular substance be all that is desired then a few ounces passed at any time will suffice. The urine should be examined within a few hours after its secretion, although a second examination is many times important after the urine has been allowed to stand eighteen or twenty-four hours. Four or five ounces of the urine should be poured into a tall, cylindrical glass vessel, and allowed to remain for a sufficient time to allow any deposit to subside. The deposit is best removed by means of a pipette or glass tube. The usual magnifying powers are all that is required. A power of 25 diameters to distinguish the large uric acid crystals and a power of 400 diameters to see the small octahedra of oxalate of lime.

The examiner should first make note of the whole amount passed in the twenty-four hours, remembering that in health even there is a wide limit. It may be said to range from thirty to sixty ounces, or even a greater range, about fifty ounces being the average.

The color of healthy urine varies from a pale-yellow to a reddish-yellow, red, or brown; or it may be almost colorless, like water. The pale urine is generally neutral or alkaline in reaction and is frequently observed in perfect health after copious drinking. High colored urine is more usually acid in reaction and has a greater amount of solid constituents. This occurs in perfect health when the amount of water excreted by the kidneys is diminished, as after profuse perspiration, or after hearty meals. It is the kind of urine found in nearly all febrile diseases. As abnormal coloring agents to the urine there are the blood and bile pigments, indican, urohæmatin, and

uroerythin. There are also various coloring agents introduced from without with the drink, food, or medicine. Among these are especially, santonin, rhubarb, and senna.

The odor of urine is affected by various matters and it is of no material value to the physician.

Normal urine is either clear or only very slightly cloudy. When it is turbid it is evidence that there is some abnormal condition. It may be due to the presence of pus, mucus, or epithelium, or to the various sediments.

Normal urine generally turns blue litmus red, that is, it has an acid reaction. It may have an alkaline or neutral reaction. If the urine has an alkaline reaction the red litmus paper will become blue; if the blue paper be allowed to dry and in so doing turns red again, then the cause is due to the presence of a volatile alkali; or if a volatile alkali be present then a glass rod moistened in hydrochloric acid and held over the urine will cause a white cloud to arise. If the blue color remains after drying then the cause lies in the presence of a fixed alkali. If the alkaline reaction of the urine be temporary, a few hours each day or for a whole day now and then, it does not bear with it any great value, and it must be regarded rather as a physiological condition. If the urine be permanently alkaline, however, much aid to a diagnosis can be derived from the fact. Rademacher calls a condition where the urine is constantly alkaline "an iron affection," that is, an affection calling for tonic remedies.

The specific gravity of the urine varies from 1005 to 1030. If it remains persistently below 1010 and at the same time contains no sugar, the case is one of *diabetes insipidus*. When the specific gravity is below 1015 it should be tested especially for albumen; but when it is 1030 and above, it should be tested for an excess of urea and for sugar.

If the urine be turbid and has a sediment after standing it should be tested for albumen. About a drachm of the urine is placed in a narrow test-tube and from ten to fifteen drops of strong nitric acid added; if albumen be present it will be precipitated. To a similar portion of the urine in a test-tube heat is applied and the albumen, if present, is precipitated. The urine should always have an acid reaction before applying the

heat-test; if it be not already acid it can be made so easily by adding ten or fifteen drops of nitric acid to the drachm of urine. It should be borne in mind that if a very little nitric acid be added to albuminous urine and heat applied, no precipitate of albumen will occur; the nitric acid should be added in excess, ten or fifteen drops to the drachm of urine.

Some of the resinous matters, as cubebs, turpentine, etc., might be mistaken for albumen. These are differentiated from albumen by adding some alcohol to the specimen; if the turbidity disappears by so doing, it denotes the presence of these resinous matters.

The microscope is of aid in examining the following:

First. Substances that float on the surface of the urine or are diffused through it.

Second. Light and flocculent deposits.

Third. Dense and opaque deposits.

Fourth. Crystalline and granular deposits.

Belonging to the first-class are the fatty matters found in the urine. Fatty matters often get into the urine accidentally, however it may be found in the molecular state as in chylous urine; or in the form of oil globules in cases of fatty degeneration of the kidneys; or it may be found in casts. Beale reports cases where cholesterine was found in the urine with the fatty matter which passes in fatty degeneration of the kidneys. The crystals of cholesterine are rectangular or rhomboidal, very thin and transparent, with regular borders, and frequently marked by a break at one corner. The crystals have a great tendency to break in parallel lines; this property with their transparency and the parallelism of their borders renders these crystals very characteristic.

THE LIGHT AND FLOCCULENT DEPOSIT.

Mucus.—This is observed in healthy urine, after it has been allowed to stand a few hours, as a bulky, flocculent deposit, which shows under the microscope a few granular, circular cells, not unlike the white corpuscles of the blood, and a transparent substance which may show a few very thin interlacing fibrils.

Spermatozoa.—These are easily recognized by their char-

acteristic shape. They are indestructible in the urine, sink to the bottom of the vessel, and cannot be confounded with anything else. They become of value to the microscopist in this connection largely from a medico-legal point of view.

Vibriones, Bacteria.—These little bodies appear in urine that has been allowed to stand for some time, but are sometimes developed before the urine has left the bladder. They possess very active movements and the larger ones twist about after the fashion of a serpent.

Vegetable fungi.—Certain forms of torulæ are developed in urine, especially in diabetic urine where they may be found in less than twenty-four hours after the secretion of the urine. Penicillium glaucum is not uncommonly met with in acid urine containing albumen. The spores of these fungi appear as round or oval globules, averaging the $\frac{1}{2500}$ or $\frac{1}{3000}$ of an inch in diameter. They afterwards become united in chains overlapping one another and giving rise to a fine network of fibrils. Masses of fungi, spores and mycelium are found in the urine of patients laboring under disease.

Epithelium.—A great variety of epithelium is found in the urine, from the large scaly cells from the vagina to the small cylindrical or spindle-shaped cells from the ureters. The cells are generally nucleated, will take carmine staining, are rendered pale and their nuclei prominent by acetic acid.

Casts.—Casts are usually mixed with pus, epithelium, and blood-corpuscles, and they are found in urine containing a considerable quantity of albumen.

Mucous Casts.—Mucous casts are found in urine of high specific gravity, with excess of urea and urates. The casts are large, averaging $\frac{1}{600}$ to $\frac{1}{400}$ of an inch in diameter, pale, and transparent, and are not colored by carmine.

Epithelial casts.—These casts are found in cases of acute nephritis, and they are accompanied with much loose epithelium and with a considerable deposit of uric acid. They may have in them oil globules, blood-corpuscles, and perhaps pus corpuscles.

Waxy casts.—These are very pale and transparent and have well defined margins. Owing to their transparency they are easily overlooked. They are colored by carmine. They may

be more easily detected by adding to the urine a few drops of a solution of iodine in iodide of potassium; this will give the casts a brownish color. They vary in size from the $\frac{1}{500}$ to the $\frac{1}{1200}$ of an inch in diameter. The casts have a smooth, waxy, glistening appearance under the microscope.

Granular casts.—Casts may be composed of a large number of granules with but few, if any, epithelial cells. These are found in the early stages of chronic nephritis. They may be so abundant as to form a deposit in the test-tube, if the urine be left undisturbed for a few hours.

Other casts are sometimes so filled with oil globules that it is all that can be seen at first. This is the case frequently in fatty degeneration of the kidney. Crystals of lime, both the dumb-bell and octahedra, and crystals of the triple phosphates have been seen in casts.

The presence of epithelial casts in the urine, for a few days only, admits of a favorable prognosis. If pus be mingled with the casts the inflammatory process is of a more severe type. Granular and hyaline casts always indicate a graver and more chronic disease. The greater the quantity of casts, and the longer they appear in the urine, so much the more extensive the degeneration and so much the graver the prognosis. If the casts contain well marked epithelial cells and blood-corpuscles, and if the granular matter in the casts be of a brown color consisting of disintegrated blood-corpuscles, and if the urine contains a large quantity of albumen, then the probabilities are that the case is an acute one. If, however, there are a number of granular casts without any brown color and a number of transparent casts, with a pale color to the urine and a small quantity of albumen, then in all probability the case is a chronic one.

THE DENSE AND OPAQUE DEPOSIT.

Pus.—The pus corpuscles appear as round, pale, granular bodies, averaging about the $\frac{1}{2500}$ of an inch in diameter. Acetic acid causes them to swell up with a smooth faint outline, and it develops in their interior from one to four small bodies. After the lapse of a few days the urine completely disintegrates the pus corpuscles.

Urate of Soda.—Urate of soda forms a very common urinary deposit, and it is found in the urine of persons in good health. It is held in solution in the healthy urine, but it is frequently precipitated. It appears, generally, in the form of amorphous, irregular, very small granules. It is slightly soluble in cold water and is readily soluble in warm water; soluble in the alkalies and in solutions of the alkaline carbonates and phosphates. If a solution of pure urate of soda be prepared and the salt allowed to crystallize, it will form small, acicular crystals. The deposit containing urate of soda varies very much in color from a pale, white cloudy precipitate to a pink, brown, or even dark red color. The urine containing this deposit is never turbid when freshly voided; it is only after the urine has cooled that the cloudiness occurs. Some of the urine is placed in a test-tube and heat applied. If the sediment dissolves, but reappears again on cooling, then it consists of the amorphous urates. The urate of soda dissolves at about 100° Fahr., while the urate of ammonia does not dissolve much below 200° Fahr. After the urine has stood for some time the supernatant fluid is poured off and half its bulk of a solution of potash added. If this causes the mixture to become clear, not viscid, then the urates of soda and ammonia enter largely into the composition of the deposit. Filter some of the boiling urine, the filtrate will give a deposit of urates when it is cool. Add some strong acetic acid to the deposit; it will be dissolved, but will soon recrystallize, which shows under the microscope the rhombic crystals of uric acid. Urate of soda is found in spherical, globular masses from the surface of which project sharp points of uric acid crystals.

Urate of Ammonia.—Under the microscope urate of ammonia appears as an amorphous deposit. When prepared artificially and allowed to crystallize, it forms delicate needle-shaped crystals collected in spherical groups, or in opaque masses with fine projecting points.

To distinguish between the urates of sodium and potassium and the urate of ammonium is very easy under the microscope. The washed sediment is treated with hydrochloric acid and allowed to evaporate on a glass slide. If the deposit be either urate of sodium or potassium then the micro-

scope will show, besides the crystals of uric acid, the cube crystals of the chloride of sodium and potassium. If the deposit be urate of ammonia then the leafy crystals of chloride of ammonium will be found. If the urate of ammonia deposit be treated with nitric acid and then filtered, and the deposit allowed to dry on the filter, and if to this dry deposit ammonia be added a beautiful purple or violet-red color will be produced. This is known as the "murexide test."

The Earthy Phosphates.—The earthy phosphates are insoluble in water and alkaline solutions, but soluble in acids. The more common forms are the triple phosphate and phosphate of lime. The phosphates are deposited from the alkaline and neutral urine, and sometimes from urine feebly acid. The most common form of the crystals of the triple-phosphate is that of a triangular prism with beveled edges. The terminal edges are sometimes also beveled; when this condition exists and when the crystal is much reduced in length, it appears almost square and closely resembles the octahedral crystal of oxalate of lime. The crystals of the triple-phosphate are soluble in acetic acid, but the octahedra of oxalate of lime are unaffected by it. The earthy phosphates are insoluble in hot water, and are unaffected by alkalies. When ammonia is added to the healthy urine the crystals assume the stellate form, consisting of from four to five or six feathery rays. Beautiful crystals of the triple-phosphate are not unfrequently found among the urates. If the turbidity of the urine be due to the presence of the phosphates a few drops of any acid will clear the specimen up. If the urine has been secreted recently, boiling will precipitate the phosphates, and acids will again render the mixture clear. If an excess of ammonia be added to the urine, agitated, and then allowed to rest, a precipitate of the earthy phosphates will be found; this precipitate can be redissolved by acids.

Phosphate of Lime.—Phosphate of lime is found in pale urine having a faintly acid reaction, with a tendency to alkaline fermentation. It is frequently associated with the oxalate of lime. It crystallizes as small rods, either singly or in stellate groups, or arranged in the form of bundles or rosettes It may be composed of needle-shaped crystals, crossing each other at right angles and lying together. The deposit may be

granular in character or it may occur as small spherical masses in the form of dumb-bells. Phosphate of lime is precipitated by alkalies as an amorphous powder.

THE CRYSTALLINE AND GRANULAR DEPOSIT.

Uric Acid is deposited as a sediment only when the urine has an acid reaction. The sediment is never colorless, although it may have but a pale-yellow color. It has, usually, either a deep yellow, an orange, or a brown color. The unaided eye is generally sufficient to identify the presence of uric acid, for it is the only substance giving a spontaneous deposit of brown crystals. The crystals usually lie scattered as colored specks on the sides of the glass vessel, forming also a layer of deposit at the bottom. It appears in many different forms under the microscope, the more common being that of smooth tables of the rhombic form. These rhombic crystals are modified by having their angles rounded off in such a way that spindle-shaped crystals are produced. Other varieties exist, as dumb-bells, six-sided plates, rectangular tables, saw-shaped, fan-shaped, etc. If there be any doubt as to the nature of any particular form it is only necessary to dissolve the sediment on the glass-slide in a drop of potassic hydrate, and then add a drop of hydrochloric acid, when the usual form will appear. Uric acid is insoluble in hot water but soluble in alkalies, potash, soda and ammonia. Some of the sediment, supposed to be uric acid, may be placed on a slide and a drop of strong nitric acid added to it. After evaporating it to dryness, one or two drops of ammonia are added. If a purple-violet or violet-red color appears it denotes the presence of uric acid or a urate. In testing for an excess or for a deficiency of urea the quantity of urine passed in twenty-four hours should be taken into account. If the amount passed be below the average it should be diluted with water until it reaches that point; if the quantity be in excess of this average then it should be evaporated to that point. After proceeding thus, if the urine has a specific gravity over 1030, an excess of urea may be the cause. To test for this, place enough of the urine in a test-tube to fill it an inch in depth; add to this one-third its bulk of pure nitric acid, and set in a cool place, or in cold water, better always in water near the freezing point. If crystals of nitrate of urea form in a few moments then an

excess of urea is present. Nitrate of urea crystals are colorless, flat, rhombic or hexagonal plates, closely united to one another.

To test for a deficiency of urea, take some of the urine, of normal quantity, and reduce it to one-half its bulk by slow evaporation; when cool add nitric acid as given above, and set in cool water. If no crystals of nitrate of urea form in five minutes then the normal amount is not present. This is a very simple method, is easily applied, and approximates the true results.

Oxalate of Lime.—Urine containing oxalate of lime has usually an acid reaction and a high color. The deposit is scanty and generally conjoined with uric acid and the urates. After the urine has been allowed to stand for a short time a drop of the colorless, mucous-like deposit is placed on a slide and examined with a high power of the microscope. The drop of urine to be examined should be taken from a little above the bottom of the vessel, for the mucous deposit at the bottom appears to hold these crystals in its upper part; they are in the greatest abundance just in the upper part of the mucous deposit. The crystals of oxalate of lime are very characteristic and cannot be mistaken for anything else found in the urine. It is to be borne in mind that some of these crystals are very minute indeed, appearing only as angular points. This salt usually crystallizes in well defined octahedra, but sometimes it is found in the dumb-bell form. The dumb-bells of oxalate of lime are readily told from those of uric acid both by microscopic and chemical methods. The uric acid dumb-bell is dissolved at once in dilute potash solution while the oxalate of lime dumb-bell is insoluble even in boiling potash solutions. Again, after the uric acid dumb-bell has been dissolved by the potash, if an excess of acetic acid be added the characteristic rhombic crystals will appear.

Oxalate of lime is insoluble in water, alcohol, alkalies, and the vegetable acids, hence it can be readily distinguished from the phosphates which are soluble in acetic acid.

This salt is soluble in the mineral acids and in the acid phosphate of soda. The octahedra of chloride of sodium can be distinguished easily from the oxalates by the fact that the former are readily soluble in water, and that the urine must be evaporated to show them.

Cystine.—Cystine is a very rare deposit. It forms a whitish sediment which consists of colorless, transparent, six-sided plates or prisms. These crystals are soluble in ammonia and upon spontaneous evaporation of the ammonia the crystals are again deposited unchanged in shape. As uric acid crystals are not soluble in ammonia this test serves to differentiate between the two. Cystine is insoluble in acetic acid, while the earthy phosphates are soluble. The surfaces of the crystals of cystine are frequently marked with lines of secondary crystallization.

They are also often seen overlapping one another and united by their sides. Cystine is insoluble in boiling water, in carbonate of ammonia, in strong acetic acid and in weak hydrochloric acid. It is soluble in the strong mineral acids, in ammonia, potash, and oxalic acid.

Carbonate of Lime.—Carbonate of lime is occasionally found in the crystalline state. It occurs in an amorphous form, and is recognized by its effervescing when acetic acid is added to it. Before applying this test the deposit should be washed with distilled water to remove any soluble carbonate that might be present.

Blood-corpuscles.—When blood-corpuscles are in the deposit they give to it a red, or brownish-red, granular, or smoky appearance. The deposit should be examined for the characteristic corpuscles. It should be remembered that the blood-corpuscles may become very much altered in their appearance by remaining in the urine for a considerable time. If no blood-corpuscles can be detected then the guaiacum test can be applied. A few drachms of the tincture of guaiacum are mixed with an equal volume of oil of turpentine and well shaken until an emulsion is formed. The urine is carefully added to this mixture. As the urine comes in contact with the emulsion a precipitate is formed. The precipitate is at first white, later it becomes yellow or green. If the urine contains any blood, even slight traces of it, the precipitated resin will be colored a more or less intense blue, many times an indigo-blue.

TO TEST FOR SUGAR.

The quantity of urine in diabetes, secreted during the twenty-four hours varies from eight to fifteen or more pints. It usually

has a pale straw color and a high specific gravity. The specific gravity is almost always above 1030 and it may be as high as 1060. Sometimes, however, the specific gravity is below normal; hence this is no sure guide as to the amount of sugar present. Deposits are rarely observed in diabetic urine.

To test for sugar, it should be first ascertained if there is any albumen in the urine. If heat and acid show that no albumen is present then apply Trommer's test at once. If albumen be present then add a few drops of acetic acid to the specimen and boil. Filter, and neutralize the filtrate with carbonate of sodium and apply the test of Trommer. If the urine has an alkaline reaction then boil it in a test-tube with a small quantity of sodic hydrate or potassic hydrate. Filter and apply Trommer's test to the filtrate.

Two solutions are necessary to carry out the test of Trommer; a solution of sulphate of copper, ten grains to the ounce, and a solution of caustic potash, of twenty-five per cent. strength.

A drachm of the urine is placed in a test-tube and three or four drops of the copper solution added; then nearly half as much of the potash solution as there is of urine is added; enough of the potash solution should be added to completely dissolve the precipitate at first formed. The clear blue solution is now heated to the boiling point. If the precipitate be either blue or black it denotes an absence of sugar; if the precipitate be yellow or brown or brownish-red then sugar is present.

There are various modifications of Trommer's test. One of the best modifications is that of Fehling. Fehling's solution is made as follows: "69 grains of sulphate of copper are dissolved in 345 grains of distilled water, to this solution a concentrated solution of 268 grains of tartrate of potash, and then a solution composed of 80 grains of carbonate of soda in an ounce of distilled water are added; water is added in sufficient quantity to make 1,000 grains." To use this solution it is only necessary to add about an equal bulk of it to the suspected urine in a test-tube and boil the mixture. If sugar be present a similar precipitate will occur to that from Trommer's test.

Fehling's solution should be kept in tightly corked bottles and protected from the light. After having been kept for some time this solution may deposit the suboxide when boiled alone ; if this should be the case some fresh potash should be added before testing the urine.

THE PRESERVATION OF THE URINARY DEPOSITS.

Urinary deposits may be preserved in Canada balsam, in glycerine, in a 1 per cent. solution of carbolic acid, in equal parts of glycerine and camphor water, in a solution of naphtha and creasote and in various other media.

The naphtha and creosote solution is of very general use It is made as follows :

Creasote,	3 drachms.
Naphtha,	6 ounces.
Distilled water,	64 ounces.
Prepared chalk,	a sufficient quantity.

Mix the naphtha and creasote together, then add as much of the chalk as may be necessary to make a thin, pulpy mass; the water is now added gradually, the whole being well rubbed together in a mortar. One or two small pieces of camphor are added and the whole mixture is allowed to stand two or three weeks in a closely covered vessel, being frequently stirred. At the expiration of this time the clear fluid is poured off, and filtered if necessary, and preserved in well corked bottles.

When any urinary deposit is to be mounted in a fluid the following method should be carried out: The sediment is allowed to settle in the test-tube, when as much as possible of the urine is drawn off from it by a syphon. A quantity of the preservative medium, equal in bulk to the contents of the tube, is added to the sediment and the mixture well shaken ; this is allowed to rest until the sediment settles to the bottom of the tube again. The preservative fluid is now drawn off, as was the urine, and a fresh quantity of the fluid added. By so doing the deposit is thoroughly impregnated with the preservative medium.

Casts are preserved very well in the naphtha and creasote solution. The very pale casts show much better by coloring them with the carmine solution.

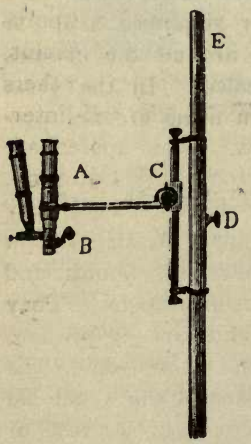
Phosphate of lime is preserved in the naphtha and creasote fluid. The crystals of the triple phosphate are preserved the best in water to which a little chloride of ammonium has been added. Cystine is preserved either in glycerine jelly or in the naphtha and creasote solution.

The urates and uric acid are preserved in the naphtha and creasote solution also. Crystals of uric acid show nicely when mounted in Canada balsam. To mount them in balsam, they must first be thoroughly washed with distilled water and then carefully dried. They are dried the best under a bell jar over sulphuric acid. When dry, a drop of oil of turpentine is added, and this is allowed to nearly evaporate when a drop of Canada balsam is added and the slide gently warmed. Care must be exercised here that the heat be slight, otherwise the crystals will be cracked in every direction. These crystals show very nicely when mounted in this way. Crystals of oxalate of lime are best preserved in the naphtha and creasote solution.

Many of the crystals obtained from urine are preserved the best in a dry state. Such are urea, nitrate of urea, oxalate of urea, creatine, creatinine, and many others. These crystals are allowed to form upon the glass slide, when they are thoroughly dried under a bell jar over sulphuric acid. A shallow ring of white zinc can be placed around the crystals and the cover applied and hermetically sealed. In the great majority of cases the crystals obtained from urine are not preserved in their mother liquid.

The Microscope in Parasitic Diseases of the Skin.

While the microscope is an indispensible aid to the diagnosis of certain parasitic diseases of the skin, it is also of great value in the examination of non-parasitic skin lesions *in situ*. For an examination of the skin only low powers are necessary with special mountings. In many cases a good bi-convex lens of low power will answer the purpose. When a higher power is required, the binocular microscope described by Dr. Pifford of New York is to be employed. A description of this instrument is given in "Pifford on Diseases of the Skin," published by MacMillan & Co. The publishers kindly furnished us with a cut of this instrument. The ingenious physician can take the low powers of his microscope and mount a monocular after the fashion of the illustration without material cost. With this instrument the skin can be examined when the patient is in any posture, and with much accuracy and ease. In cases of eczema and psoriasis it is many times exceedingly difficult, almost impossible to make a differential diagnosis, but the matter is rendered much more simple by the aid of the microscope. There are many other skin diseases that can be diagnosed by the microscope.



It is, however, among the parasitic diseases where the microscope is of most value. The parasites investing the skin belong both to the vegetable and animal kingdom, and are called respectively vegetable and animal parasites. The diseases due to a vegetable parasite are designed by the term

"tineæ." There are the following varieties : tinea favosa, tinea circinata, tinea tonsurans, tinea sycosis, and tinea versicolor.

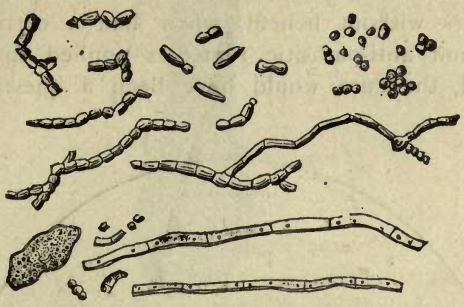


Fig. 14. Achorion Schönleinii.

Tinea favosa, *favus*, or crusted ringworn, is due to the presence of a vegetable parasite called *achorion* Schönleinii. See fig. 14. Under a power of four or five hundred diameters this parasite is seen to consist of both mycelium and spores in great quantity. The mycelium is composed of narrow tubes or threads of varying length. It is usually very abundant. It differs greatly in appearance with the stage of its growth, for the tubes may appear perfectly empty or they may contain spores, in which case they are called "receptacles" or "spore-tubes." These tubes look like links of chains, some of the links being found single, in others united, two or more together, and all intermingled with the spores. The spores are very irregular in shape; they may be round, oval, dumb-bell, or flask-shaped. They vary in size from $\frac{1}{2500}$ to $\frac{1}{5000}$ of an inch in size. They are highly refractile bodies and have a grayish or pale-greenish color. They exist in vast quantities and are everywhere present in the specimen examined. This fungus is the most luxuriant of the vegetable parasites. To examine for them, a small part of a crust or hair should be placed on the slide and covered with the thin glass. A drop of liquor potassae is placed to the edge of the cover and allowed to come in contact with the specimen. A

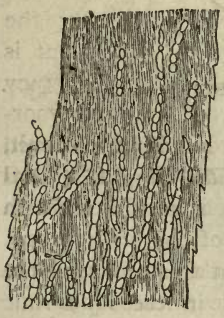


Fig. 15. Split Hair-shaft showing spores.

magnifying power of about four or five hundred diameters is sufficient to show the features already described.

Cases of tinea have been treated *per ora* for months and even for years without benefit, when had a correct diagnosis been made and anti-parasitic remedies applied directly to the parts affected, the cure would have been a question of a few weeks.

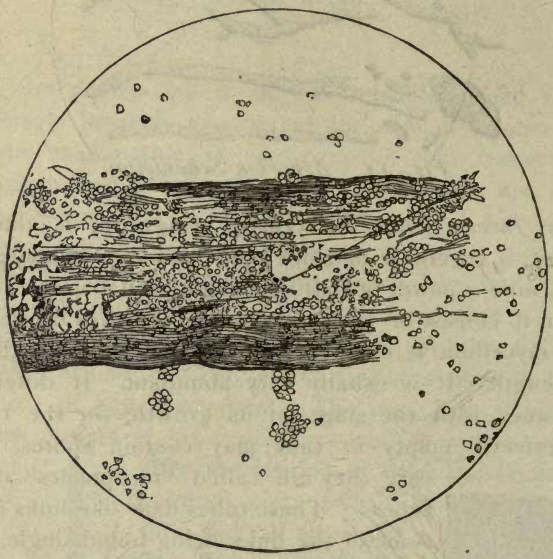


Fig 16. Hair in Tinea Tonsurans.

Tinea circinata, *tinea tonsurans*, and *tinea sycosis*, are caused by a vegetable parasite known as the *trycophyton* fungus. This fungus consists of mycelium and spores which vary a trifle in each of the three affections.

Tinea Circinata, ringworm of the scalp. In this affection the mycelium is most abundant and is embedded in the epidermic cells. It consists of very long, slender threads, having a sharp outline and containing spores and granules. A single thread not unfrequently extends entirely across the field giving off branches in every direction. The spores of the fungus in tinea circinata are highly refractile bodies of a pale-green or grayish-color. They are small and round or rounded. They never assume

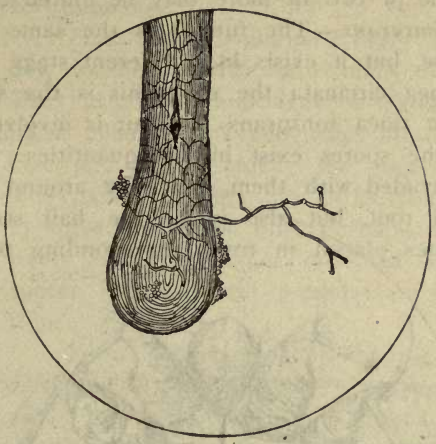


Fig. 17. Hair in first stages of Tinea Tonsurans.

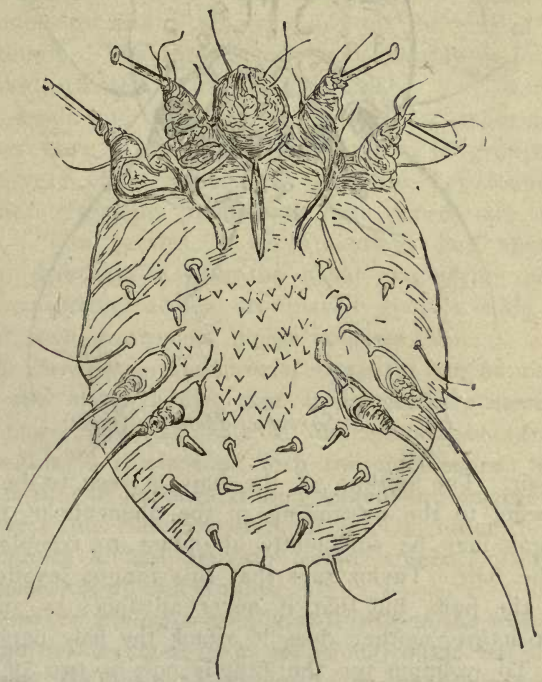


Fig. 18. Sarcoptes Hominis (female).

the many shapes characteristic of the *achorion* Schönleinii. They may be single or two or more may be united together.

Tinea Tonsurans.—The fungus is the same as in the last named disease, but it exists in a different stage of its development. In tinea circinata the epidermis is the seat of the disease while in tinea tonsurans the hair is involved. In the latter disease the spores exist in vast quantities. The hairs are thoroughly invaded with them, not only around the outside of the bulb and root, but also inside the hair structure. They are many times placed in rows corresponding to the filaments

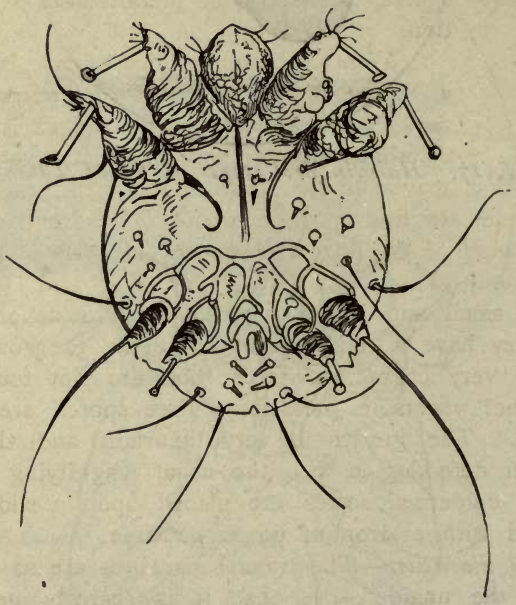


Fig. 19. Sarcoptes Hominis (*male*).

of the hair. The outline of the hair is seen to be ragged in places, owing to the protruding of the filaments of the fungus. The fungus may be sufficiently abundant to completely disintegrate the hair. Taylor says that this fungus invades the hair down to the bulb, but that it never advances to any distance in this structure, neither does it attack the hair papilla or root sheaths. To examine for the fungus one or two of the short

stumpy hairs should be placed on a glass-slide, covered and treated with liquor potassae.

Fig. 20. Demodex Folliculorum.

Tinea Sycosis.—Barber's itch. The hairs are dry, swollen, brittle and many times twisted. They are loose and may be extracted without pain. The fungus penetrates into the hair follicle and affects chiefly the roots of the hair. The parasite differs but little from that found in tinea tonsurans only perhaps there is relatively more mycelium in tinea sycosis. The spores, however, still predominate in this affection.

Tinea Versicolar.—This disease is caused by a vegetable parasite, known as *microsporon furfur*. The mycelium of this fungus is composed of short, slender threads, that may be either empty, or that may contain a few spores and granules. It is not uncommon to find a single spore on the end of a thread of the mycelium. The threads vary considerably in form, being found jointed, twisted, straight, or crooked and wavy. The spores are small and irregular in shape as in achorion Schönleinii. They have a tendency to aggregate in groups. These masses are very characteristic, as they are not found in any of the other vegetable parasites. Free spores are met with everywhere. The growth is very luxuriant and there is no difficulty in detecting it with the usual magnifying power. A few of the epidermal scales are placed upon a slide, covered. and treated with a drop of liquor potassae.

Animal Parasites.—The animal parasites are so readily detected by the unaided eye that it is scarcely necessary to mention them. The itch mite is the least liable to be detected, but this is easily seen with the microscope. On turning one out of the pustules from between the fingers with the points of very fine needles and placing it under the microscope the minute animal *sarcoptes scabiei* is seen. It gives rise to the disease known as scabies.

The *Demodex Folliculorum* (fig. 20) inhabits the sebaceous follicles of healthy skin, hence gives rise to no trouble. If one of the follicles about the nose or forehead be squeezed rather hard,

and the contents placed on a glass-slide with a drop of olive oil, and then covered with the thin glass, one or more of these parasites may be found. The oil causes the hard portions around the parasite to separate from it when it can be emoved to a separate slide.

Fig. 21.
Pediculus Capitis.

Fig. 22.
Pediculus Pubis.

Fig. 23.
Pediculus Corporis.

Pediculosis.—There are three varieties of this disease, designated according to the names of the species of pediculi. The pediculus capitis, or head louse; the pediculus corporis, or body louse, and the pediculus pubis.

TUMORS.

THE INFLAMMATORY new formations are very unstable and when their cause, usually some irritation, is removed they will have a strong tendency to return to a healthy standard or condition. The non-inflammatory have great independence, grow by an inherent activity of their own, and are constantly tending to become removed farther and farther from a healthy condition. Their general tendency is to increase in size, although after a time they may remain permanent. To this class belong the new formations, known as tumors. A tumor is many times pathological simply because its specific elements occur in a place where they do not normally belong. Virchow calls a tumor composed of but one tissue "histioid," when composed of several tissues "organoid." When in addition to the latter there are organ-like tissues "systematoid."

If a new formation occurs in a tissue agreeing with it in structure it is said to be "homologous." If unlike it, it is "heterologous."

All of the pathological elements found in a new formation, including the cells, nuclei, matrix, vessels, etc., are prototypes of those found in the normal tissues, only undergoing change and destruction more readily.

The cells of these growths are reproduced most frequently by cell division, the nucleus dividing first, followed by a division of the formed part of the cell. This has been observed to occur in a very few seconds. Sometimes the nucleus alone will divide, these nuclei thus formed dividing again and again, until one cell may possess in this way from four to twenty or more nuclei.

These cells are known as the "giant," "mother," or "myeloid" cells. They are found normally in the medullary substance of bone.

Pathological cells, then, come from pre-existing cells, and when newly formed are usually small and round, having a nucleus or composed of nucleus matter alone, simple undifferentiated protoplasmic

cells. At this stage it would be impossible to tell the future of the growth. Like the small cells of the embryo, they are entirely undifferentiated. These cells may be the round cells of a sarcoma or the cells of connective tissue.

As soon as a tumor is completely developed it is liable sooner or later to undergo some of the forms of degeneration. If it has been of short duration, attained a considerable size, and if it is composed largely of cells, then it will undergo these changes all the more rapidly. If it has been of slow growth and its elements are developed into tissue, then it will not be liable to degenerate. Fatty degeneration is most commonly met with. This is probably due to the fact that in the rapid formation of new tissue there is not a proportionately new formation of blood-vessels, and as a result of the insufficient circulation and want of nutritive material, the fatty metamorphosis occurs.

Tumors may also undergo pigmentary degeneration, usually from a deposit of melanin. This is a black, or nearly black, substance found physiologically in the skin and eye. It is seen either as free granules in the tumor or deposited in the cells. It does not appear to be at all susceptible to reagents, and its origin is probably the same as that of hæmatoidin. In caseation the fluids are absorbed and the elements are dried up, changed into a yellowish cheesy material, which process may continue until the whole mass may become surrounded by a capsule of fibrous tissue. In calcification, small calcareous particles are infiltrated through the mass. Sometimes softening liquefies the whole mass into a thin liquid, which under the microscope is seen to consist of broken down material, granular matter, fat, etc.

Colloid and mucoid degenerations also occur when the albuminous ingredients are transformed into substances chemically resembling mucin and an allied colloid material.

A tumor is malignant when it has a tendency to recur in the same or some distant place after its removal.

It is innocent when this tendency is not present. The term "malignancy," then, is purely a clinical one and does not refer to any property of the growth to destroy life. The heterologous character of a growth is an evidence of its malignancy.

In the examination of tumors the fresh cut surface should be scraped and this examined for cells: their shape, number, size,

nuclei, the size and number of nuclei in each cell, all should be carefully noted. Then the tumor should be cut in small pieces, not over one-half an inch square, and placed at once in dilute alcohol, to be replaced in a few days by common methylic alcohol, and if the tissue still remains too soft for cutting thin sections, stronger alcohol may be added for a day or two. Müller's fluid may be employed, but at this laboratory the best results have been obtained by the use of alcohol alone. In two weeks the tissue will be of sufficient consistence to allow thin sections to be made with the aid of a razor. By holding the piece of tissue firmly between the thumb and fingers of the left hand, the razor held in the right hand can be drawn from heel to point over the tissue, cutting the section sufficiently thin for examination. Or by using one of the embedding mixtures already given the piece may be embedded in the microtome and sections cut as has been described. The arrangement of the fibres and cells should be noticed, together with any alveolar stroma that may be present.

Carmine and hæmatoxylin are useful staining reagents.

The sections are best preserved, after staining, by clearing them in the oil of cloves and mounting in balsam or damar.

It is very difficult to make a satisfactory classification of the new formations. The classification given in T. Henry Green's "Pathology and Morbid Anatomy" is as free from objections as any with which we are acquainted. It is here given with slight changes:

CLASSIFICATION OF TUMORS.

I. Type of the fully developed connective tissues.

Type of fibrous tissue, - - -	Fibroma.
Type of adipose tissue, - - -	Lipoma.
Type of cartilage tissue, - - -	Enchondroma.
Type of bone tissue, - - -	Osteoma.
Type of mucous tissue, - - -	Myxoma.
Type of lymphatics, - - -	Lymphoma.

II. Type of higher tissues.

Type of muscle, - - - -	Myoma.
Type of nerve, - - - -	Neuroma.
Type of blood-vessels, - - -	Angioma.
Type of papillæ, - - - -	Papilloma.
Type of secreting glands, - -	Adenoma.

III. Type of embryonic tissue.—The sarcomata.
Spindle-celled sarcoma.
Round-celled sarcoma.
Myeloid sarcoma.
IV. The carcinomata.
Scirrhus.
Encephaloid.
Colloid.
Epithelioma.

FULLY DEVELOPED CONNECTIVE TISSUE.

Of the two kinds of corpuscles found in connective tissue, the movable, or wandering kind, is the most important in this connection. In size, contractility, ability to wander, etc., they seem identical with the white blood corpuscles. In all probability they have their origin in the blood. It is not known whether they can pass into the regular connective-tissue corpuscle or not. Neither is it known in what channel they move.

TYPE OF FIBROUS TISSUE.

Fibroma, fibroid or connective tissue tumor. This tumor consists of quite distinct fibres that are without any arrangement, and that are separated only with difficulty. If the section be made across a blood-vessel the fibres will be seen running in a circular manner around it. Only a few cells will be found, and these are most abundant in the neighborhood of blood-vessels. They are usually of the spindle-shaped or stellate variety. Nuclei that take the staining readily are seen distributed over the field. As a rule there are but few blood-vessels, but it sometimes occurs that the walls of the vessels have become firmly united with the structure of the tumor, hence if the growth be cut into or injured severely the mouths of the vessels will not be able to contract and profuse hæmorrhage results.

In size the fibromata vary from a very small circumference to an immense growth. Their form is also varying. The fresh cut surface is usually dry, only in the rapidly growing younger growths when a serous or mucous fluid exudes. Arising from the skin they are usually softer and less dense than those found in other parts, and in this situation are usually single. They are generally limited

by a capsule and have a slow growth, occurring in middle and advanced life. They increase in size by a central growth, by a multiplication of their own elements, and do not invade the surrounding healthy structure.

They are then innocent growths and cause disturbance to the organ or tissue in which they are situated and to the whole organism only from their size. The fibromata are not liable to undergo degeneration. Fatty degeneration, calcification, mucoid softenings and hemorrhages are met with usually affecting only a part of the growth. Growing beneath the skin these tumors are sometimes soft, without a capsule and multiple. They are known here as wens. Nasal polypi are a variety. So is a tumor often described as a neuroma, which under the microscope is seen to consist not of true nerve tissue, but of fibrous tissue. These growths usually commence from the connective tissue surrounding the nerve, the neurilemma, and by increasing in size, either press upon the nerve proper or grow around it, and thus, as they increase in size they compress the nerve. They are generally small, round, hard tumors that are painful in the extreme. Uterine fibroids are rarely composed of fibrous tissue. They will be described under muscular tumors. The fibromata are frequently combined with other forms.

TYPE OF ADIPOSE TISSUE.

In structure a lipoma resembles ordinary adipose tissue, consisting of large cells that are fully distended with fat. The nuclei of the cells are not visible unless the fat be dissolved from the cells, or unless a cell is found containing but very little fat. They vary in size, frequently attaining a most enormous growth. The fresh cut surface shows fatty tissue. It occurs most frequently in parts where fat normally exists, rarely in other parts, is usually sharply circumscribed, encapsuled, grows slowly and with a central growth. It has no tendency to return after removal.

It rarely undergoes any of the degenerations, and when occurring only small parts are affected.

TYPE OF CARTILAGE.

Enchondroma, chondroma. This tumor is rarely found composed of cartilaginous tissue alone, but usually combined with connective tissue. It may be either hyaline, reticular or fibrous cartilage, or all three combined. The number and size of the cells are very

variable. Some are spindle-shaped, some stellate and movable. Usually, however, they resemble the cells of normal cartilage. The enchondromata vary in size, are usually single, occasionally multiple. They occur in the early part of life, even in the new born. By far the greater number affect the bones and most frequently the medulla. Thus the articulating surfaces are rarely affected. They may arise from cartilage itself: their likeness to normal cartilage is then more exact. In some of the softer forms there is a tendency to return after removal, affecting even the lymphatics, and in the young causing cachexia. The malignant properties of the encondromata, when present, are probably due to the fact that sarcomatous elements are associated with them. However healing almost invariably occurs after complete extirpation, and in the case of a pure enchondroma malignancy may be said to be entirely absent. Of the many degenerations to which this tumor is subject calcification is the most common. Ossification sometimes affects the periphery of the growth so that it is surrounded by a thin bony wall. Spiculæ of bone are frequently found through the growth. A specimen in the author's possession shows about one-third of the growth truly ossified, the remainder resembling normal cartilage. The line between the two being sharp and distinct.

TYPE OF BONY STRUCTURE.

Osseous tumor, Osteoma. In the case of this tumor the bony appearance is the natural result of development, whereas in many other cases—tumors having undergone osseous degeneration—it is accidental. It has an independent growth and is not to be confounded with the products of inflammation of bone, as the callus after fractures, etc. Most of the osteomata arise from connective-tissue. They may have their origin from cartilage, bone, or the periosteum of bone. Those having their origin apart from bone, heterologous, are known as osteophytes. They are found near diseased joints, near the seat of inflammatory processes and in many other situations. They are found not uncommonly in the lungs and brain. They are to be carefully distinguished from growths that have become partly ossified, for in the latter case they might be more or less malignant, while a true osteoma is perfectly innocent. The homologous exostoses are found most frequently on the external and internal surfaces of the skull, in the orbit, on the up-

per and lower jaw, etc. They are troublesome only when some neighboring part is affected by pressure. The appearance under the microscope is not unlike that of the true bone, at least the lacunæ and canaliculi are present, although not arranged in any order.

TYPE OF MUCOUS TISSUE.

Myxoma, mucous tumor, tumor mucosus, gelatiniform or colloid sarcoma. A myxoma consists of a mucous basis substance in which are spindle-shaped or stellate cells which anastomose with each other. A few are round or oval or spherical. This is very generally the case in the younger growths. If young and rapidly growing the number of these cells will be largely increased proportionately. A nucleus is seen in each of the cells. Sometimes two nuclei are present. The refracting power of the mucus is so great that some care is necessary in order to see the outlines of the cells. Staining will be of advantage here. The cells are easily obtained by simply scraping the cut surface and adding a little saline solution to the scrapings. They are closely related to cells found in the sarcomata, and by many are so classed. The same kind of tissue exists in two places in the body physiologically, in the vitreous humor of the eye and in the umbilical cord.

The myxomata usually occur as single tumors, and are generally round, uniform and small. The fresh cut surface may show septa of connective tissue, giving the growth a soft but quite firm consistence, or the connective tissue may be nearly, if not entirely absent. There will then escape a viscid mass of mucilagenous consistence to such a degree that the whole tumor will become flattened and formless. Their most favorite seat is in the adipose tissues, and they are here generally encapsuled. The growth is usually slow, although they are many times of extraordinary size. The walls of the blood-vessels are very thin and liable to rupture. Hence the frequency with which sanguineous cysts are met with.

The cells themselves may become destroyed by either fatty or mucoid degeneration. As a rule the myxomata are innocent growths. Sometimes, however, they exhibit malignant properties. This probably is due to the fact that many times these growths are combined with others, especially the sarcomata.

TYPE OF LYMPHATIC TISSUE.

Lymphoma, Lymphadenoma. It is not very unlike a lymphatic gland in structure, consisting of a basis of distinct fibres which branch and cross each other like a net-work, and of cells identical with the white blood corpuscles. These cells fill up the space in the basis, but in a thin section they can be all removed by brushing it well with a camel's hair brush moistened in water. The firmness of the tumor will depend upon the comparative amount of basis fibres and nucleated cells. If the growth is young and increasing rapidly in size then the cells will be the more prominent part of the growth. Later the number will diminish and the reticulum become thicker and firmer. These tumors not infrequently acquire a large growth even infiltrating the surrounding tissues. They are homologous primarily, and become heterologous only from the new tissue extending into surrounding parts, or from their growing in a place where the lymphatics are very small and few in number.

The lymphomata are innocent growths and are not liable to undergo degenerative changes. In the disease known as "Hodgkin's disease" the new growths in various parts of the body are like the one described. The enlargement of the spleen in leukæmia is of the same nature.

TYPE OF MUSCULAR TISSUE.

Myoma. A tumor composed of striated muscle is one of the rarest of the new formations. A myoma composed of smooth or non-striated muscle is most frequently met with in the uterus, where it is generally known as a "uterine fibroid," and when projecting into the cavity of the uterus or extending by a pedicle out of the neck is called a "uterine polypus." The muscle cells form one but not the only element. Connective tissue may exist in great abundance. This is especially the case in the older growths. In the new growths it is not uncommon to find almost exclusively the characteristic non-striated muscle cells. There are few blood-vessels distributed through the connective tissue. These are homologous growths, of slow growth, usually single, but often multiple. They are liable to undergo softening, or more frequently to become calcified. They are perfectly innocent, exhibiting no tendency to return after removal.

TYPE OF NERVOUS TISSUE.

Neuroma. These consist of true nerve fibres and are not the growths so commonly met with growing from the sheath of nerves or within the sheath. They are composed of ordinary medullated nerve fibres associated with connective tissue. They are found on the ends of divided nerves, growing after amputations. They are usually very small nodules, innocent, and are remarkable largely for the great pain they cause.

TYPE OF BLOOD-VESSELS.

Angioma. These tumors are composed of blood-vessels held together by connective tissue. The diagnosis is readily made without the aid of the microscope.

Fig. 24. Papilloma.

TYPE OF PAPILLÆ.

Papilloma, papillary or villous tumor. This tumor consists of a body of connective tissue with a covering of epithelial cells, resembling the papillæ of the skin. They are rarely without blood-vessels, which end either in a capillary net-work or in a single loop. Cells may be seen scattered through the connective-tissue basis. The epithelial covering is generally like that from which the part arises. The papillomata may occur on any surface of the body, but more generally where papillæ and villi normally exist. They occur

singly or many papillæ may be affected, giving the growth a cauliflower appearance. The papillomata exhibit no tendency to return after removal, yet in many ways they may become serious troubles. They are liable to undergo ulceration, followed by hemorrhage, especially when situated in the bladder and intestine. Warts of the skin, common warts and horny growths are varieties of this class, so also are the condylomata and venereal warts. This growth will not be mistaken for an epithelioma, for in the case of a papilloma, epithelial cells are in their normal relations to the part, they are homologous, while in an epithelioma the cells are heterologous.

TYPE OF GLAND TISSUE.

Adenoma, glandular tumor. In structure an adenoma is like that tissue in which it is found, or from which it originated, for it

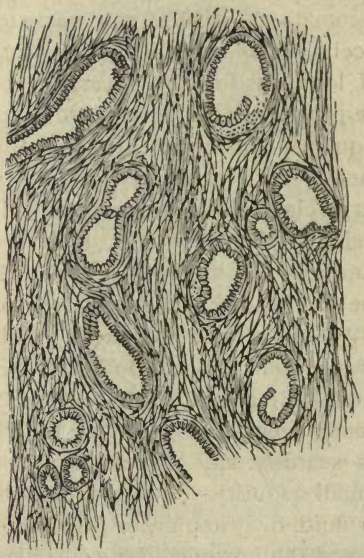


Fig. 25. Adeno-fibroma, from mammary gland.

may, after a time, become completely separated from the old gland. Its function will not be like the normal gland however. Indeed it can be said to have no function whatever. The adenomata are very difficult tumors to diagnose, being very liable to undergo the degenerations, especially the formation of cysts and the changing into calcareous forms. They are frequently, perhaps most frequently,

found in the female mammæ. They are very commonly associated with other forms, as adeno-sarcoma, adeno-myxoma, etc. In the mammary gland an adenoma is most frequently associated with a fibroma, giving rise to the familiar adeno-fibroma. Here the aceni of the gland are separated from each other by a large growth of fibrous tissue between them, or a bundle of aceni may be separated from another bundle by a hypertrophy of the intervening connective tissue. This may develop to such an extent that the secreting tubes of the gland will be nearly obliterated.

The growth of these tumors is usually slow. While they are primarily innocent they may assume malignant properties.

TYPE OF EMBRYONIC TISSUES, THE SARCOMATA.

Fibro-cellular, fibro-plastic, fibro-nucleated, recurrent fibroid, myeloid. The sarcomata are divided into varieties according to the majority of their cells. The spindle-celled sarcoma is composed almost entirely of long fusiform, comparatively thick-bodied, nucleated cells. The processes from either end of the cell are usually long and not infrequently branched. Each cell is possessed with one nucleus frequently with two nuclei. This variety is the most common of this large class of new formations. The spindle-shaped cells vary much in size, both in the same growth and also in different growths. Some growths will be composed almost entirely of cells averaging $\frac{1}{1500}$ of an inch in length, while others of much larger cells, of twice the size, with larger nuclei, and some growths combine the two. The cells are many times arranged close together, so that there is scarcely any space between them, giving but a small quantity of intercellular substance, which in turn may be either fluid, or granular, or firm and fibrillated. Large cells, large nuclei, and the presence in a cell of more than one nucleus, are evidences of a high degree of malignancy. The cells are not infrequently arranged parallel to each other, running in bundles all through the growth, giving it very much the appearance of a fibroma. This tumor arises as do all the sarcomata, from pre-existing connective tissue, and increases, either by multiplication of its own elements (central growth), or by continually invading the healthy tissue around it (peripheral growth), which is highly char-

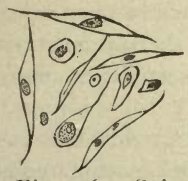


Fig. 26. Spindle-cells, from sarcoma of leg.

acteristic of all this class. The sarcomata are usually quite vascular, the walls of the blood-vessels being composed of embryonic tissue render them exceedingly liable to rupture, causing the formation of sanguineous cysts, severe hemorrhage, etc. They are also very liable to undergo fatty degeneration. Although this variety may become encapsuled, it possesses unmistakable malignant properties. The growth is usually rapid.

The cells of a melanotic sarcoma are mostly spindle-shaped and nucleated, but they now contain a large amount of dark colored pigment, melanin, rendering the nuclei obscure, and many times invisible. The large majority of these growths is found primarily in the eye, where this pigment normally exists. They may arise from the superficial integument. Sometimes this pigment will be deposited only in a slight degree, giving the growth a brownish appearance. Then too, only a few of the cells may be thus affected. Again the pigment may be in such excess that the tumor will be a black color. These tumors are very liable to have their elements conveyed to distant parts by the blood-vessels, in which case their melanotic character will accompany them. In this way secondary growths are found in the liver, kidneys, lungs, etc. The laboratory is in possession of a liver three-fourths of which has become transformed into little melanotic growths, varying in size from a pea to masses two inches in diameter. This variety of the sarcomata is perhaps the most malignant of all, exceeding in this particular many of the cancers.

An osteoid sarcoma is usually a spindle-celled sarcoma that has either become truly ossified, or more or less hardened by calcareous deposits. It is important to recognize the sarcomatous element, inasmuch as the innocence or malignancy of the growth will depend upon it. Some acid, as dilute hydrochloric, may be used to dissolve out the calcareous matters when it can be examined for the characteristic cells, which, if found, will decide its malignancy.

A sarcoma composed of round cells is usually of much softer consistence than one composed of spindle cells. Such a sarcoma is composed of true embryonic connective tissue, with a fine granular intercellular substance. The smallest cells take carmine staining evenly, evidently consisting of nothing but free nucleus matter. The larger cells have a nucleus while the largest have frequently two nuclei, with nucleoli. The cut surface yields a juice rich in

cells. This variety increases with a rapid growth by invading the healthy surrounding structures, involving the lymphatics and internal organs. It is full of blood-vessels easily ruptured. It is not to be mistaken for encephaloid cancer, which it resembles by physical characters. Here the cells are of a nearly uniform size and character, and there is an entire absence of an alveolar stroma. When an alveolar stroma is present careful attention must be given to notice whether the cells are grouped together in these alveolar spaces or exist singly and alone. If the latter then it is termed an alveolar sarcoma, if the former, it belongs to one of the cancers. It is often very difficult to distinguish between the two. A myeloid sarcoma is usually found growing in connection with bone, especially from the medullary cavity. The nuclei vary in number from two or five to ten or fifty. These large cells are generally separated from each other by a number of cells of the spindle-shaped variety, among which are seen a few round or oval ones. It is quite frequently encapsuled, most frequent in early life, and is the least malignant of all the sarcomata.

Thus it will be seen that all the sarcomata possess malignant properties, in this respect ranking next the cancers. They disseminate by means of the blood-vessels, and thus rarely infect the lymphatics, a clinical distinction between these growths and the cancers, marked and distinct. For this reason they are reproduced with greater rapidity than the cancers. The lungs are the most favorite seat for the secondary growths. No one variety of the sarcomata is necessarily malignant, while again the same variety may recur in the same place many times.

THE CARCINOMATA.

A cancer is a growth consisting of a fibrous, alveolar stroma, the meshes of which are filled with cells of an epithelial type. While the cells have no "specific" character, yet they are recognized by their large size, irregular shape, the prominence, number and size of their nuclei and nucleoli. These cells exhibit every possible shape. They are full of granular matter, and from their great liability to undergo fatty degeneration they usually contain some fat globules. In the juice of the cancers will be found numerous free nuclei, especially in the younger and softer growths. Cells not very unlike these are found in the normal tissues or in those tissues when

slightly inflamed. The day of the "specific cancer cell" is nearly over, in fact there is no such thing at the present time, the very best pathologists hold strictly that "every pathological growth has its physiological prototype."

If cells are found in a growth of the character described above, then that growth must be looked upon with suspicion, but before pronouncing it a cancer two other things must be carefully noted ; first, the stroma, and second, the arrangement of the cells within the alveoli. The stroma, or solid portion of the cancer generally consists of a frame-work of connective tissue so arranged that round or oval alveoli are formed, freely communicating with one another, in which

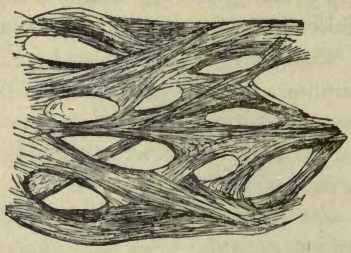


Fig. 27. Stroma of Scirrhus.

are grouped together the cells described above. The amount of stroma varies exceedingly. Sometimes it is so great as to form the largest part of the tumor. The alveolar spaces are then very small, and the growth will be hard to the touch, and the cut surface will yield but little juice. Again it may be very scanty as in the rapidly growing and young cancers. Every possible degree as to quantity exists. Cancers have been found in all tissues save cartilage. The female mammæ, uterus, lower lip, stomach, liver, œsophagus and lymphatic glands are all favorite places for the development of the cancers. They may occur alone or in great number, and appear as tumors or as infiltrations. They are very rarely separated from the healthy tissues surrounding them by a capsule, but on the contrary show a close connection with them.

The blood-vessels are arranged very different from those found in the sarcomata. In the latter it will be remembered the vessels ramify all through the growth, and their walls being composed of embryonic connective tissue, they easily rupture and then the elements

are easily and rapidly disseminated. While in the former—the cancers—the blood-vessels course within the stroma and very rarely indeed do they communicate with the alveoli. Thus, it is very rare, if ever, that the cancers are disseminated by means of the blood-currents. However a study of the lymphatics shows them to be numerous, accompanying the blood-vessels and communicating freely with the alveolar spaces. The elements thus enter the lymphatics readily and are carried to the nearest glands where they are caught in its meshes and are carried further on, not, however, until the gland itself has become sufficiently affected to furnish other elements. In the cancers, then, dissemination is slow and accomplished through the lymphatics. All cancers are very liable to undergo fatty metamorphosis, especially the young and rapidly growing varieties.

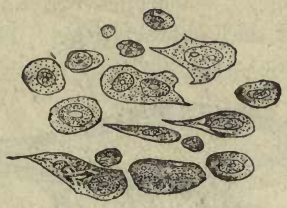


Fig. 28. Cells from Scirrhus.

Scirrhus or chronic cancer, as its name implies, is of slow growth and of a firm and hard structure. In this variety the alveoli are small and comparatively poor in cells. Instead of the organs affected being increased in size they are many times actually reduced, often depressed in the centre and firmly attached to the skin. A microscopical examination of the centre of this growth may reveal nothing but cicatricial tissue. The cells have suffered degeneration, while the stroma has atrophied and contracted. At the periphery will be found a zone of cells, and free nuclei infiltrating the neighboring tissues. Between the two will be seen the characteristic alveolar stroma together with the cells. Its most frequent seat is in the female mammæ and in the stomach. The secondary growths arising from it are generally encephaloid.

Encephaloid or acute cancer differs from the above mostly in its rapid growth and small amount of stroma. It is usually very soft and by scraping the fresh cut surface an abundance of juice is given off, rich in cells, free nuclei, granular matter, etc.

STARCH.

STARCH is the most generally diffused, excepting protoplasm, of all vegetable substances within the cell-wall. When found in the older structures, roots, stems, seeds, etc., it is found nearly pure; when found in freshly-growing tissue it is in union with chlorophyll. Starch grains contain carbon, oxygen, hydrogen, and some mineral matter. They are insoluble in water, alcohol, ether, and oil; are destroyed by potassa, and colored blue or violet by iodine—the color depending on the density of the granule and the strength of the iodine. The starch grains of different families and different species of the same family differ so much in size and general appearance as to be easily identified. The largest starch grains known are those of tous-les-mois, which are frequently $\frac{1}{300}$ of an inch in length, while the smallest are those of rice, which are occasionally $\frac{1}{800}$ of an inch in diameter.

Potato Starch.—Botanists have taken the potato-starch grain as the typical form with which they compare others. If the commercial starch is not accessible, the grains can easily be obtained by cutting a fresh potato with a clean knife, and then floating on a glass slide, with a drop of water, the white substance which adheres to the side of the knife. Or, shave off a very thin slice of the potato, and place it in a watch-crystal in a little water; the fine sediment settling to the bottom will be the starch. There are two leading theories regarding their growth. Some claim that the surface of the grain is formed first, and that it grows by layers being deposited on the inner surface of the case, which gradually expands until it reaches its normal size. The other and the more generally accepted opinion is, that the nucleus is formed first, and the grain grows by means of deposits of starchy matter around this nucleus, and each successive layer contains less moisture than the preceding layer; this explains the appearance of rings or laminæ seen so plainly in the potato and many other starches. A new theory has been advanced in Sach's Botany

(page 59), which is too long, however, for an explanation in this connection. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain, and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. The grains are round, ovate, irregularly oval, or egg-shaped, nearly transparent; nucleus eccentric and in the smaller end of the grain, and surrounded by numerous distinct rings or laminæ. The grains are very irregular in size; the

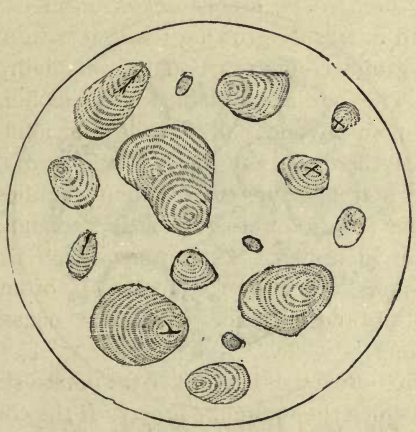


Fig. 30. Potato Starch. x375.

smallest are just perceptible, and the largest are frequently $\frac{1}{400}$ of an inch in length. A very decided cross is seen when viewed with polarized light, the arms of the cross radiating from the nucleus, not from the centre of the grain. This is the cheapest and the most common starch; there being from $800,000 to $1,200,000 worth thrown on the market annually. Probably the greatest part is used for adulterations.

Arrow-root Starch closely resembles potato-starch. The grains are much more uniform in size than those of the potato, and are about $\frac{1}{800}$ of an inch in length. The nucleus is generally in the larger end of the grain, while in the potato-starch, as before mentioned, it is in the smaller end; while the rings are finer and more

STARCH.

STARCH is the most generally diffused, excepting protoplasm, of all vegetable substances within the cell-wall. When found in the older structures, roots, stems, seeds, etc., it is found nearly pure; when found in freely-growing tissue it is in union with chlorophyll. Starch grains contain carbon, oxygen, hydrogen, and some mineral matter. They are insoluble in water, alcohol, ether, and oil; are destroyed by potass and colored blue or violet by iodine—the color depending on the density of the granule and the strength of the iodine. The starch grains of different families and different species of the same family differ so much in size and general appearance as to be easily identified. The largest starch grains known are those of tous-les-mois, which are frequently $\frac{1}{100}$ of an inch in length, while the smallest are those of rice, which are occasionally $\frac{1}{800}$ of an inch in diameter.

Potato Starch.—Botanists have taken the potato-starch grain as the typical form with which they compare others. If the commercial starch is not accessible, the grains can easily be obtained by cutting a fresh potato with a clean knife, and then floating on a glass slide, with a drop of water, the white substance which adheres to the side of the knife. Or, shave off a very thin slice of the potato, and place it in a watch-crystal in a little water; the fine sediment settling to the bottom will be the starch. There are two leading theories regarding their growth. Some claim that the surface of the grain is formed first, and that it grows by layers being deposited on the inner surface of the case, which gradually expands until it reaches its normal size. The other and the more generally accepted opinion is, that the nucleus is formed first, and the grain grows by means of deposits of starchy matter around this nucleus, and each successive layer contains less moisture than the preceding layer; this explains the appearance of rings or laminæ seen so plainly in the potato and many other starches. A new theory has been advanced in Sach's Botany

(page 59), which is too long, however, for an explanation in this connection. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain, and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. The grains are round, oblate, irregularly oval, or egg-shaped, nearly transparent; nucleus eccentric and in the smaller end of the grain, and surrounded by numerous distinct rings or laminæ. The grains are very irregular in size; the

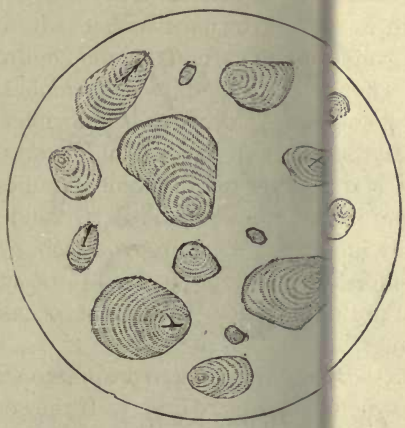


Fig. 30. Potato Starch. ×375.

smallest are just perceptible, and the largest are frequently $\frac{1}{400}$ of an inch in length. A very decided cross is seen when viewed with polarized light, the arms of the cross radiating from the nucleus, not from the centre of the grain. This is the cheapest and the most common starch; there being from $800,000 to $1,200,000 worth thrown on the market annually. Probably the greatest part is used for adulterations.

Arrow-root Starch closely resembles potato-starch. The grains are much more uniform in size than those of the potato, and are about $\frac{1}{800}$ of an inch in length. The nucleus is generally in the larger end of the grain, while in the potato-starch, as before mentioned, it is in the smaller end; while the rings are finer and more

numerous. Thirty or forty rings can frequently be counted in one grain, while potato-starch sometimes has only three or four. Arrow-root starch takes a distinct cross with polarized light It is very frequently adulterated with potato starch.

Wheat Starch.—Pure wheat starch can be obtained by cutting through a kernel of wheat, and scraping with the point of a knife a little from the central part of the kernel on a glass slide. There are two distinct kinds of grains found here ; small spherical or angular grains floating frequently in a mass, many times more numerous than the large grains, and about $\frac{1}{500}$ of an inch in diameter. The

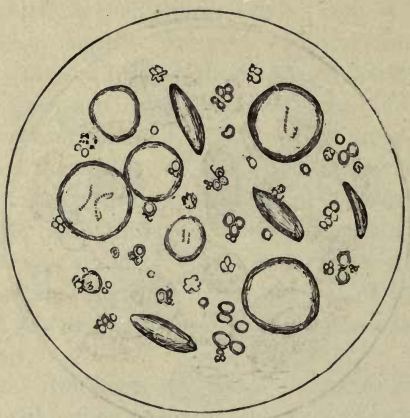


Fig. 31. Wheat Starch. x375.

others are large, lenticular grains, which, when viewed on the face, appear like a spherical grain. When viewed on the edge, they have the appearance of a double-convex lens. This lens shape can easily be proved by touching the cover glass gently with a pencil-point, and watching the grains roll over in the field. This should always be done when testing for adulterations with starch grains. There is seldom any nucleus, but when it is present it is central, and still more seldom are there any rings. When viewed with polarized light, only a faint cross is seen if any.* When subjected to dry heat, the grains are changed very much in appearance; being warped considerably from their normal shape. They are larger, more brittle, and

*The statement is made by some botanists that wheat starch gives a cross under polarized light, but I have never been able to detect any closer approach to one than a nearly uniform shadow floating over the grain.

more transparent. Yet generally they can be identified when subjected to either dry or moist heat, if the moist heat be not raised to the boiling point. The large grains of wheat starch, in their normal state, are very uniform in size for the same variety, but the starch-grains of the different varieties differ considerably in size. The average diameter of the grain in the eight varieties examined is $\frac{1}{981}$ of an inch.† Barley and rye are closely related to wheat. All of these are used extensively for adulterations.

Barley Starch is composed of large and small grains. The large grains are smaller than those of wheat; being about $\frac{1}{1600}$ of an inch

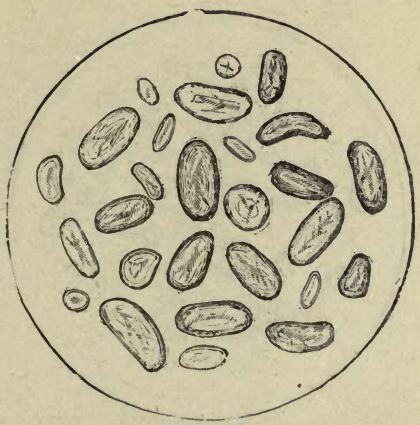


Fig. 32. Bean Starch. x375.

in diameter. There is less difference between the long and the short diameters than in wheat starch, so that when the grains are rolled over they present less of a lens-shape, being rounder. Rings and a star-shaped nucleus are quite frequently apparent. The small grains are more angular, frequently having a nucleus, and average $\frac{1}{8800}$ of an inch in diameter. No cross is seen when viewed with polarized light.

Rye Starch grains are larger than those of wheat, very seldom do they show any rings, and when present they are eccentric; occa-

†These measurements were made by Mrs. Stowell. In each case 20 grains, as nearly typical as possible, were selected, and accurately measured; the average was then taken, with the following results: The largest grains of Treadwell wheat measured 1-861 of an inch in diameter; Deihl, 1-816; Wicks, 1-881; Egyptian, 1-994; Russian, 1-1174; Clawson, 1-1256; Schaffer, 1-1000; Vienna flour, 1-861. There is also considerable difference in the size of the small grains. Schaffer small grains measure 1-4700 of an inch in diameter; Treadwell, 1-6102; Vienna flour, 1-5166; Russian, 1-400; Egyptian, 1 6000.

sionally a star-shaped and central nucleus is present. The large grains average $\frac{1}{727}$ of an inch, the small grains $\frac{1}{5717}$ of an inch in diameter. A distinct cross is seen in rye starch with the polarized light. After examining these starches in their natural condition, they should be subjected to both dry and moist heat, and examined, as their appearance is much changed by heating. As adulterants, they are frequently so treated.

Bean Starch.—We have here a very different appearance from any other starch, excepting that of the pea. The grains are regularly oval and quite uniform in size. A dark line with ragged edges

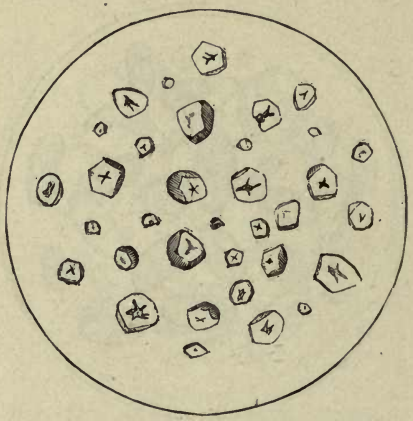


Fig. 33. Corn Starch. x375.

generally extends the whole length of the grain; cross-marks being frequently seen. Faint rings are seen near the edge of the grain. The grains average about $\frac{1}{647}$ of an inch in length and $\frac{1}{1000}$ of an inch in breadth. Dry heat renders the grains more brittle, and destroys the nucleus, but not the rings. Moist heat expands, distorts, renders more transparent, and destroys both rings and nucleus.

Pea Starch is the nearest like that of bean starch. The grains are smaller and more slender, being generally less than $\frac{1}{700}$ of an inch in length.

Corn Starch.—We come now to a starch grain bounded by plane faces and angles instead of curves. The grains are angular, have no rings, and present a round or star-shaped central nucleus. The average grain is $\frac{1}{1600}$ of an inch in diameter. The shape is only

slightly changed by dry heat, but is entirely destroyed by moist heat. The grains found in the central or outer part of the kernel of corn are more angular than those found in the inner part. This variety is frequently substituted for wheat flour, under the name of "amylum."

Rice Starch.—The starch grains of rice resemble very closely those of corn. They are much smaller, however, being only $\frac{1}{1000}$ of an inch in diameter. The grains are angular; being bounded by plane sides only, are without rings, and have a central nucleus which is either a dot, a line, or star-shaped. The grains are aggregated to-

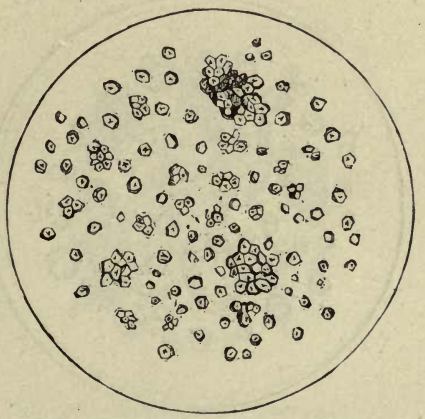


Fig. 34. Rice Starch. x375.

gether in angular or very irregular-shaped masses. Rice is used much more extensively in England as an adulterant than in America, and commercial rice flour is frequently adulterated with corn starch.

Oat Starch is the nearest like that of rice, and it is quite difficult to distinguish between them. Oat starch is both compound and simple. The compound grains or masses are oval, spherical, or egg-shaped; the surface of the masses being smooth, while those of rice are irregular. The divisions into grainlets show very distinctly. The simple grainlets are larger than those of rice; being $\frac{1}{400}$ of an inch in diameter, and bounded by one or two curved faces. They are without nuclei and without rings. A faint cross is seen with polarized light.

Buckwheat Starch is made up of both compound and simple

grains. The compound grains or masses are cylindrical or prismatic. When cylindrical, the curving surface is perfectly smooth, but the ends are irregular, as though they had been broken. These masses are very numerous and characteristic, and somewhat resemble the cell-contents of black pepper ; being coarser, however, than the latter. Black pepper is largely adulterated with buckwheat. For this reason buckwheat should be compared with some of the grains from the central part of black pepper, which can be easily obtained by scraping it out with the point of a pen-knife. The grainlets of buckwheat starch are like those of rice, in having a central nucleus

Fig. 35. Oat Starch. x375.

and no rings, and are like those of oat, in having one or more curved faces. In size, they are about $\frac{1}{300}$ of an inch in diameter. A correct knowledge of these starches, so closely related to rice, can be obtained only by faithfully comparing each under the microscope with starch from the latter source.

Sago Starch is obtained from the parenchyma or pith of several different varieties of palms. Sago appears in market in a variety of forms ; as pearl sago, white sago, sago flour, sago meal, etc. When examined with the microscope, the starch grains of sago appear quite large compared with those of the other starches. They are oval, ovate, or elliptical in shape ; much broken, generally one extremity is rounded, and the other extremity, or the sides near it,

appear to be clipped, which is due to the pressure of the adjoining starch grains. The nucleus is eccentric, as indicated by a dark cross or slit which frequently extends the length of the grain ; the surface is irregular or tuberculated; and marked by a few distinct rings, fewer than are seen in the potato-starch grain. The grains exhibit a faint cross when viewed with polarized light. The starch grains composing commercial sago are so changed by the process to which they are subjected before being ready for market, that there is little resemblance between them and the fresh grains. The starch grains found in the pearl sago are the most changed by heating. Sago is

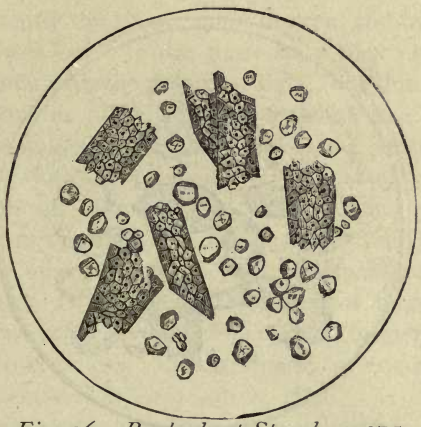


Fig. 36. Buckwheat Starch. x375.

not used so much in this country for an adulterant as in Europe. Commercial sago is frequently adulterated with potato starch, sometimes with rice. Sometimes there is an entire substitution of potato starch for the sago. Any adulteration used for sago can readily be detected by the microscope, by noticing the above described characteristics.

Tapioca Starch is prepared from manioc or cassava, or, according to Linnæus, from the root of Janipha Manihot. In the preparation of tapioca for market, the substance is subjected to a temperature of 100 degrees C., which changes the appearance of the starch grains very much from what they are in their fresh state, yet they are not entirely destroyed. The heat partially dissolves the outer case of the starch grains, which renders tapioca slightly soluble in water. The grains are quite uniform in size (about $\frac{1}{200}$

of an inch in diameter); they are round or cup-shaped, with flattenings here and there, due to the pressure of neighboring grains. The starch grains of tapioca are generally found floating in the field singly, but in the growing root they are found compounded of two, three, or four grains each. A distinct and large circular nucleus is seen in fresh specimens. In dried specimens the nucleus is marked by a distinct star or cross. Tapioca is adulterated with rice, sago, and potato starch. Potato flour is frequently prepared like pearl tapioca, and sold as such. Tapioca is used quite extensively in England as an adulterant, but not so much in America.

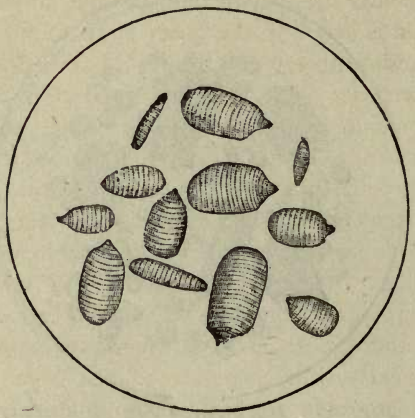


Fig. 37. Turmeric Starch. x375.

These starches, sago and tapioca, are so much changed in the different commercial varieties, *i. e.*, pearl, white, meal, etc., that to become well acquainted with them one should examine each variety carefully. An illustration or drawing of these in their fresh state would hardly be of value in identifying the starch grains as we find them in market as an adulterant.

Turmeric Starch is from the rhizome of Curcuma longa, and is imported principally from Southern Asia. The parenchyma is packed full of starch in angular or roundish masses. Turmeric is used extensively as a coloring material, to give deeper color to the spices which have been adulterated with some of the flours. When a ground spice, as, for example, mustard, contains turmeric, even if not in large quantities, its presence can be detected by expos-

ing the mustard to the light, when it will fade to a dingy yellow. Its presence can also be detected by treating the suspected substance with potassa, and if turmeric be present the substance will turn a deep yellow or brick-red color. The starch grains are quite uniform in size, and in shape are elliptical, oval, or like flattened discs, sometimes even truncated. The nucleus is at one extremity, and has the appearance of being entirely outside of the grain proper. Rings quite distinct, numerous and uniform in density, pass around the grains like zones, and present a beautiful appearance in a fresh grain. Commercial turmeric has been heated so much in preparation for market that frequently the rings cannot be seen, and even the normal shape of the grain is lost. In the fresh state they show a decided cross or black bands with the polarized light; but this is seldom seen in commercial turmeric. The coloring material is a deep, reddish yellow, and is contained in special cells of the parenchyma. The starch grains are white. The action of iodine and potassa is the same here as with all starches, but sulphuric and sulphochromic acids are of perhaps more value in this case, for they turn the coloring matter to a peculiar rose-pink. In the examination of mustard, this test is valuable. Of the twenty specimens of mustard examined, during the past two years, every one contained turmeric. It is used to color many other spices. The turmeric of commerce is itself adulterated frequently with corn starch, etc.

Ginger Starch grains are irregularly spherical, oval, or disc-shaped, closely resembling those of turmeric, belonging to the same family, Zingiberaceæ. The nucleus is at the extremity, as if it were hardly a part of the grain, the rings are numerous and uniform. A cross is seen with polarized light.

Much of the ginger of the market has been scalded, which causes the starch grains to lose their normal shape. It is difficult then to see the rings; and the cross, which was seen with the polarized light, is destroyed. In examining the starch from the root, as found in the stores, the starch grains at the centre will be found to be more perfect than those taken from near the surface of the root.*

*The following references, furnished by Mrs. Stowell, may be of value to those wishing to carry the study of the starches farther: Hassall's "Adulterations in Food and Medicine;" Sachs' "Botany," page 56; Souberian, "Dictionnaire des Falsifications;" Wiesner, "Robstoffe des Planzenreiches," pp. 239 289; Planchon, "Détermination des Drogues Simples," Vol. II. chap. XIII; Nägeli, "Die Stärkekörner," Zürich, 1858, 4°; Flückiger und Hanbury's "Pharmacographia."

THE DIFFERENTIAL STAINING OF NUCLEATED BLOOD CORPUSCLES.

THE fluids used for this purpose are two, which are designated as A and B. Their formulas are as follows:

A.

Eosin, 5 grains.
Distilled water, 4 drachms.
Alcohol, 4 drachms.

Dissolve the eosin in the water and add the alcohol.

B.

Methyl analin green, 5 grains.
Distilled water, 1 ounce.

The blood should be spread upon the slide, by placing a drop upon one end and quickly drawing the smooth edge of another slide over it. This, if well done, will leave a single layer of corpuscles evenly spread over the central part of the slide.

When the corpuscles on the slide are thoroughly dry, which will only require a few minutes, the slide should be 'flooded' with stain A.

This should be allowed to remain on for about three minutes, at the end of which time it may be washed by gently waving back and forth in a glass of clean water. Before it is allowed to dry, the corpuscles should again be flooded, this time with stain B. After two minutes exposure to this fluid, the slide should be washed, as before, and set away to dry. When dry, a drop of Canada balsam may be put upon the blood, a cover-glass applied, and the whole gently warmed until the balsam spreads out properly. When hard it may be finished the same as is usual with balsam mounts.

If now examined with the microscope, the corpuscles will be found to be well stained with red, while the nuclei and "leucocytes" will be a blueish-green.

The granular appearance, which is ordinarily seen in the nuclei, now shows with a vigor and sharpness which is difficult of description, while the whole corpuscle is as brilliant as a newly cut ruby.

This method was originally given by Prof. A. Y. Moore, and it first appeared in the August number of "The Microscope" for 1882.

EXPLANATION OF PLATE.

DOUBLE STAINED BLOOD CORPUSCLES.

1. Red Blood Corpuscles of Hawk, x 585.

2. Red Blood Corpuscles of Hyla, x 585.

3. Red Blood Corpuscles of Gull, x 500.

4. Red Blood Corpuscles of Dove, x 1060.

5. Red Blood Corpuscles of Frog, x 1060.

6. Red Blood Corpuscles of Snapping Turtle, showing granular nature of nucleus, x 2160.

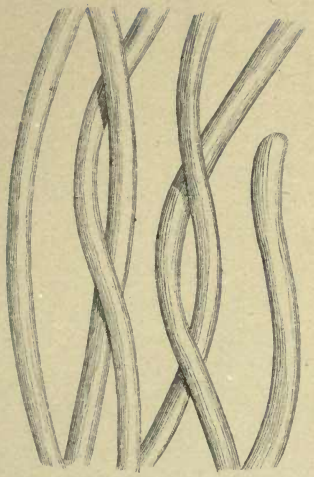
7. Red Blood Corpuscles of Toad, x 2160.

8. White Blood Corpuscles of Newt., showing nuclei connected, x 740.

9. Red Blood Corpuscles of Newt., x 2160.

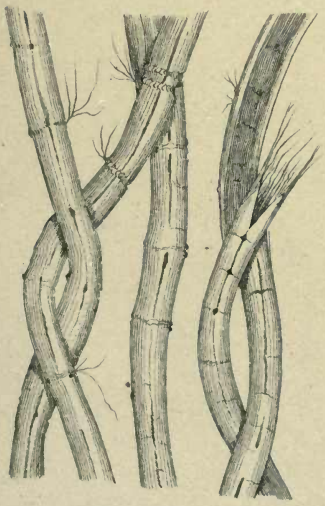
10. Red Blood Corpuscles of Newt., ruptured, x 740.

Figures 1, 2 and 3 were drawn under a $\frac{4}{10}$ inch objective. Fgures 4 and 5 under a homogeneous immersion, $\frac{1}{15}$. Figures 6, 7, 8, 9 and 10 under a homogeneous immersion, $\frac{1}{6}$.

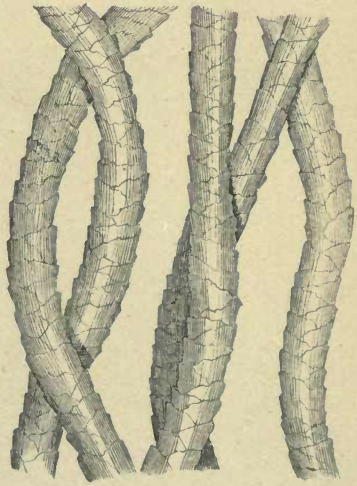


SILK.

COTTON.



LINEN.



WOOL.

L.R. Stowell, Del.

Commercial Fibres x 370.

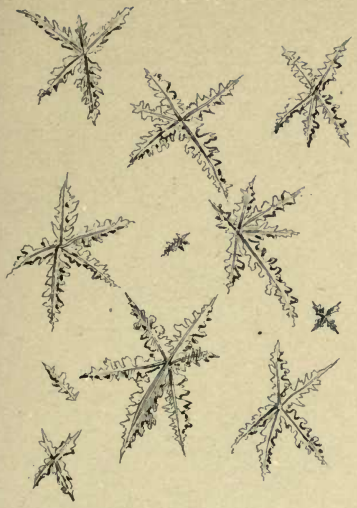
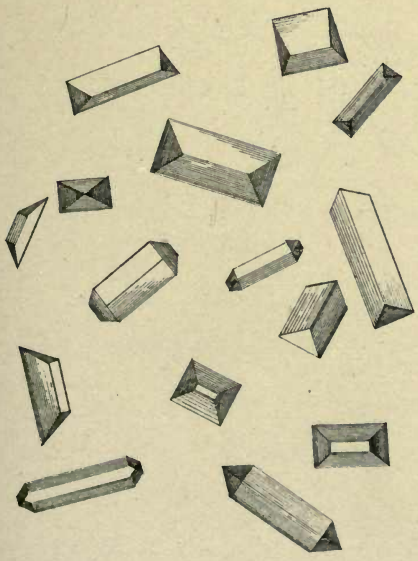


Fig 1. Crystals of triple phosphate x 50.

Fig. 2. Crystals of triple phosphate.



L.R.Stowell, Del.

Fig. 3. Crystals of triple phosphate. x 50.

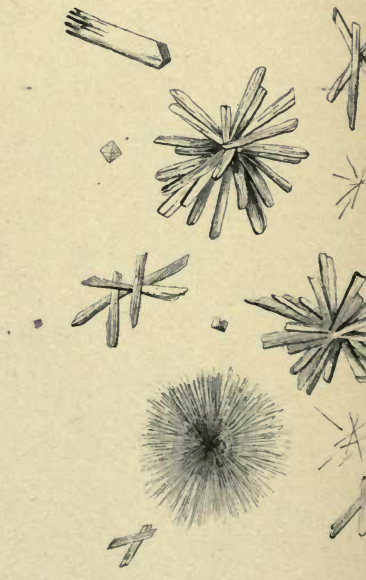


Fig 4. Phosphate of lime.

PLATE III

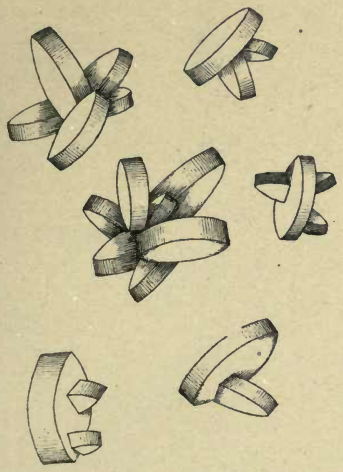


Fig. 1. Uric Acid. x 100.

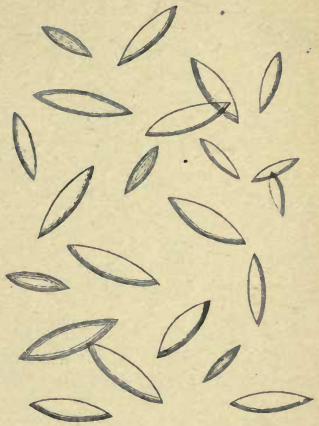


Fig. 2. Uric Acid. x 200

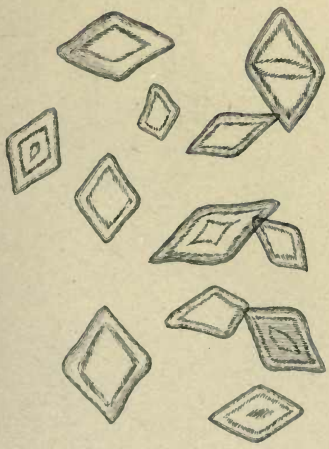


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Fig 3. Uric Acid. x 150.

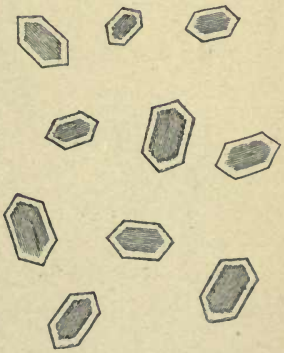


Fig. 4. Uric Acid. x 150.

PLATE IV.

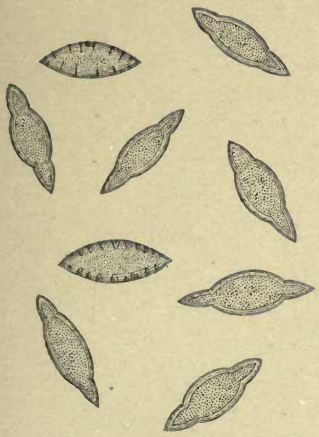


Fig.1. Uric Acid. X 125.

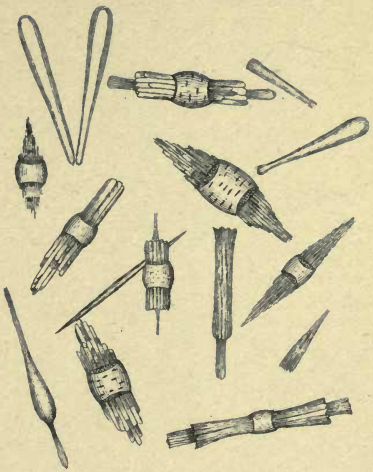
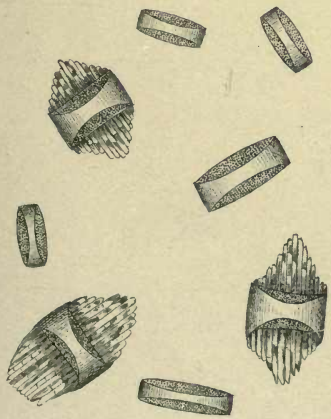


Fig.2. Uric Acid. X 75.



L.R.Stowell,Del.

Fig.3. Uric Acid X 125.

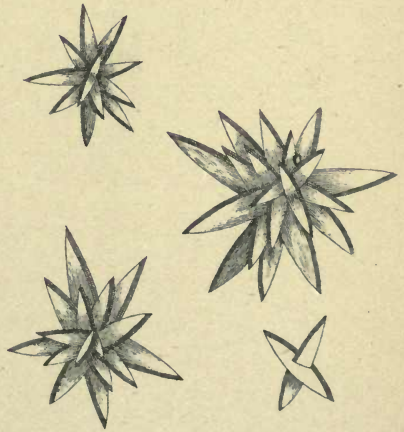


Fig.4. Uric Acid. X 125.

PLATE V

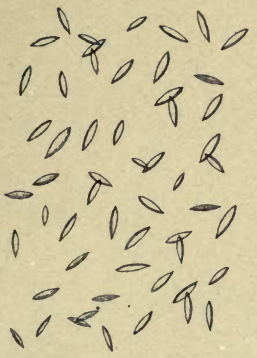


Fig. 1. Uric Acid. x125.

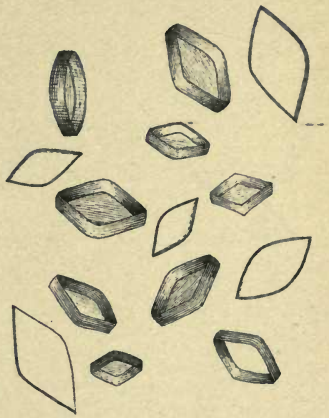


Fig. 2. Uric Acid. x75.

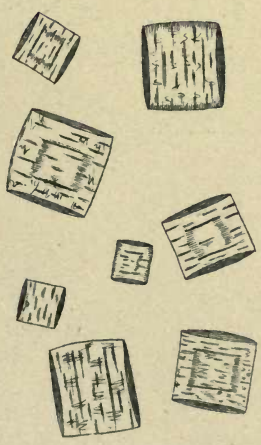


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Fig 3 Uric Acid. x 75.

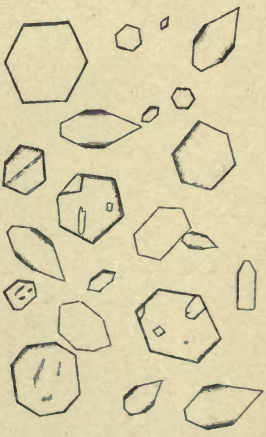

Fig 4. Uric Acid x75.

PLATE VI

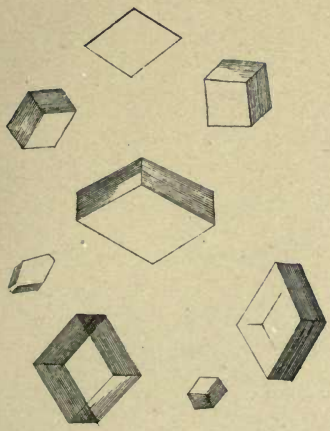

Fig. 1. Uric Acid X200.

Fig 2. Uric Acid. X 350.

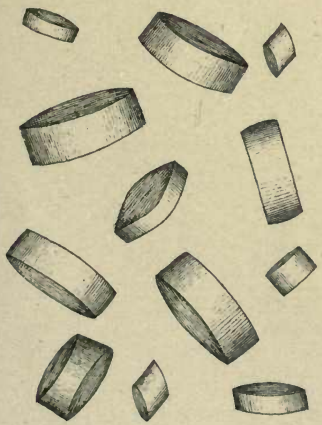

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Fig 3. Uric Acid. X 100.

Fig. 4. Uric Acid. X 100.

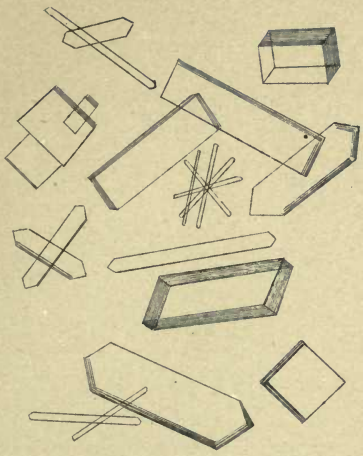

Fig. 1. Creatinine. x 75

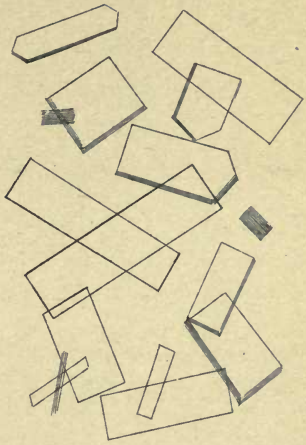

Fig 2. Creatinine. X 75

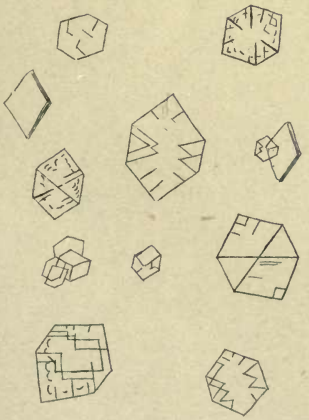

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Fig 3. Cystine. X 300

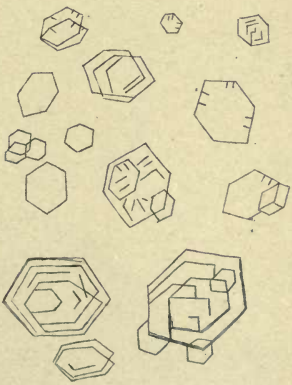

Fig 4. Cystine. X 300

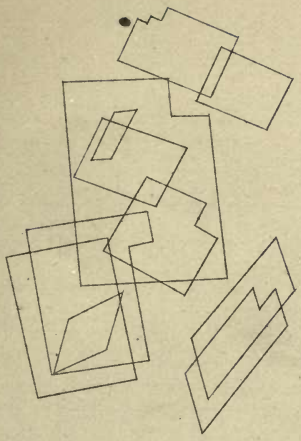

Fig. 1. Cholesterine. X 250.

Fig. 2. Tyrosine. X 150.

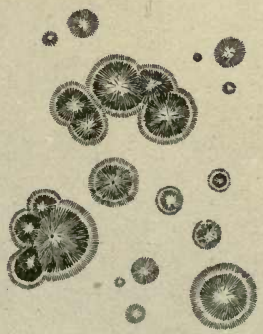

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Fig. 3. Leucine. X 200.

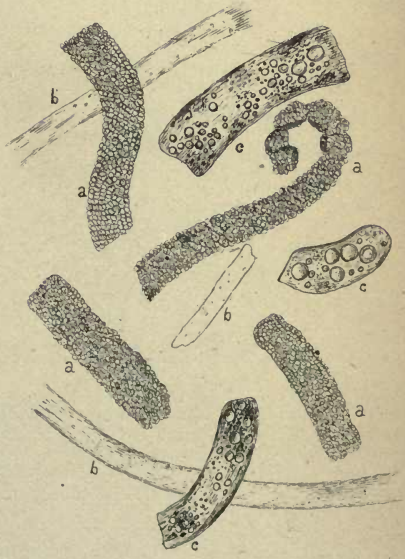

Fig. 4. Casts. X 250.

Plate IX.

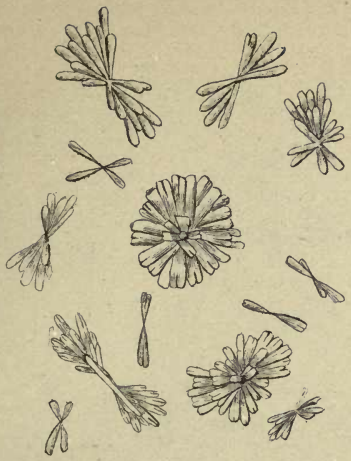

Fig. 1. Crystals of triple phosphate. X 125.

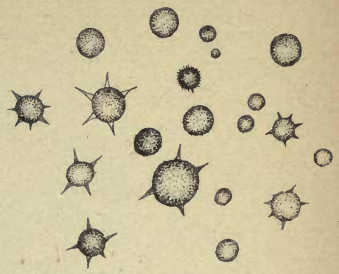

Fig. 2. Urate of Soda. X. 350.

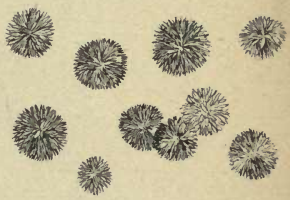

Fig. 3. Urate of Ammonia. X 250.

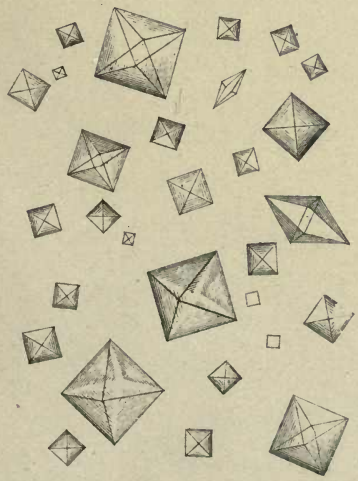

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Fig 4 Crystals of oxalate of lime. X 350.

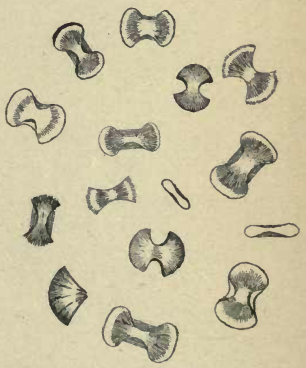
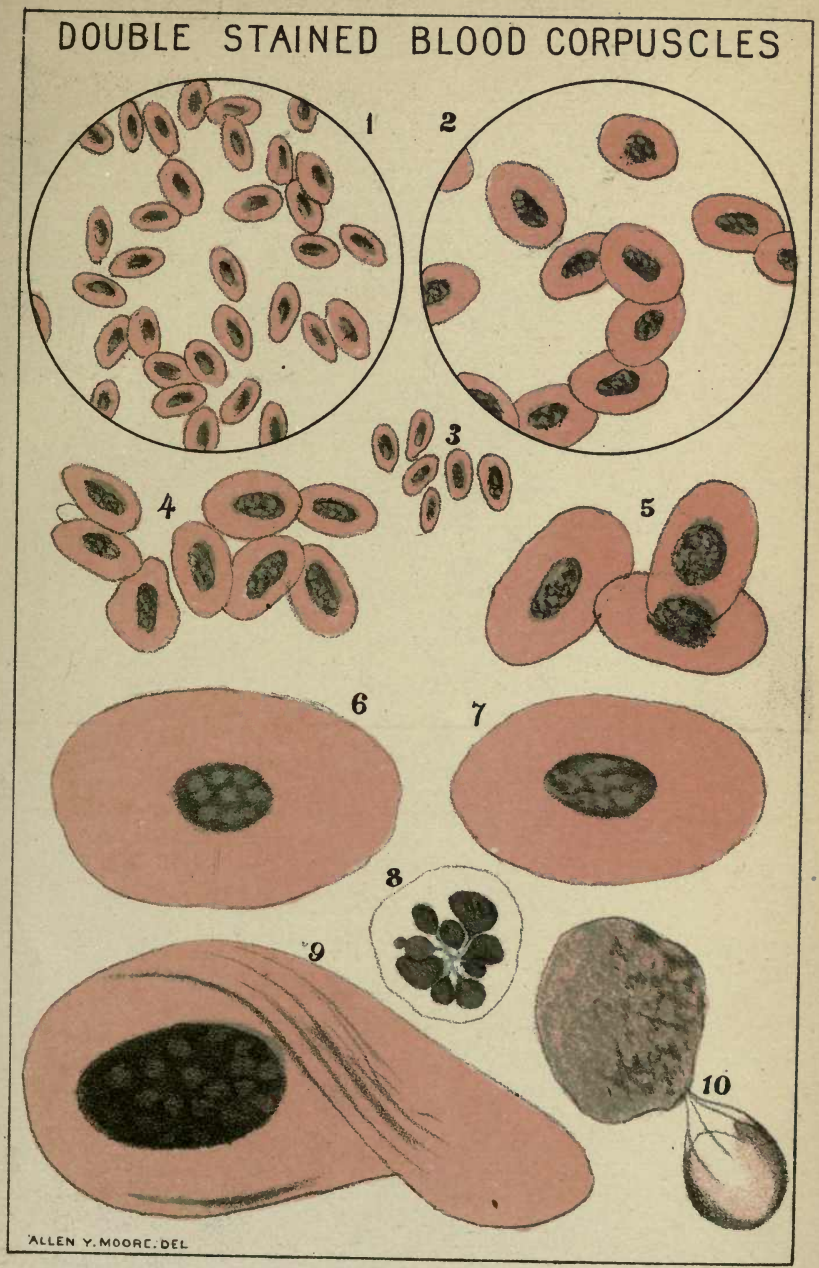


Fig. 5. Dumb-bell crystals of oxalate of lime. X 250.


DOUBLE STAINED BLOOD CORPUSCLES
1
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ALLEN Y. MOORE. DEL

PART II.

A STUDY OF WHEAT.

General Characteristics of Wheat

and the Structure of the Straw.

THE old theory, that says the best mechanics in the world are those who work most faithfully from morning till night at the drudgery of their work, and know or care for nothing else, is fast giving way, and to-day that mechanic can obtain the best situation who is most thoroughly acquainted with his work, in all the minuteness of its details, having a complete knowledge—from the intricate mechanical problems down to the mere drudgery of the business. Is there any class of workers to whom this can be applied better than to the miller?

A miller who desires to be considered successful—not particularly from a money point of view—should be familiar with the structure of every part of his mill—know the power of the stones—just how much margin he has for safety in the steam boilers—know how much strain can be brought to bear on the great leather belts, and be able to recognize and remedy at once any defect. He should know what grains he can run through his mills with safety, either to the mill or to his reputation as a miller. If it is his ambition to have the purest flour in market, he must know just what wheat to accept, not only the variety of the wheat, but the purity of that wheat, for the very best variety of wheat will not give pure white flour if the greater part of it is smut, or if it has been troubled with any of the numerous parasites which live on wheat. Then, for these reasons, our model miller should have a knowledge of the different diseases to which wheat is subject, such as smut, blight, rust, mildew, brand and ergot. A study of the history, geographical distribution and microscopic structure of wheat, will constitute the present series of articles.

Wheat has been cultivated from the earliest antiquity, and now furnishes the principal bread-stuff of all civilized countries. It is not known to what country it originally belonged; some even have claimed that it was planted upon the earth at the time of the creation. It is certain that it was cultivated in Egypt nearly two thousand years before the Christian Era as we read in the Old Testament, and Chinese history tells us wheat was introduced into China 2,700 B. C. by one of the Chinese emperors. In every country where wheat would grow at all, it has steadily increased in proportion as the country has become civilized and settled. Hostile armies have aided in transporting it from one country to another, and Mexico owes its first introduction of wheat to the brutal conqueror Cortez. It was introduced and cultivated in Peru under the direction of the Spanish lady Maria de Escobar, and the North American Colonies began to cultivate it at the earliest period of their settlement. It was first sown on the Elizabeth Islands, of Massachusetts, by Goshold, at the time he explored the coast, in 1602. It was sown in Virginia, together with other grains, in 1611; however, it was not cultivated to any great extent, because the raising of tobacco was entered into with so much zeal; but in 1651 a premium was given for its culture, when it received a great impetus.

In 1620, wheat, together with rye, barley and other grains, was exported from Manhattan Island to Holland. It was first introduced into the valley of the Mississippi in 1781. The New England states and New York did not raise scarcely any more wheat than necessary for their own use until after the Revolutionary war, but large quantities were exported from New Jersey to Europe, and from Illinois to New Orleans. The price per bushel in 1635 was sixty cents, while in 1860 it was sold for $3.25. At the present time wheat is cultivated over nearly the whole world, being limited only by the rigid cold of the North and the intense heat of the South. We find it exported in large quantities from the United States, Russia, Hungary, Turkey, Denmark and Chili. Next to the United States, it is most extensively cultivated in Russia. The great increase in the Pacific States is worth noticing. In 1850, only 17,200 bushels were raised. Now, we are told, there are many farms of from 2,000 to 4,000 acres, while farms of from 20,000 to 40,000 acres are by no means few, entirely given up to the growth of wheat.

This is due principally to the fact that the summers are long and devoid of heavy rains.

Regarding wheat with a botanical interest, we will find it in the family of *Gramineæ*—the family of grasses—and belonging to the species *Triticum Vulgare*. Of this there are two distinct sub-species, known as Summer and Winter wheat—the Summer, *Triticum æstivum*, and the Winter, *Triticum hybernum*. Each of these sub-species is divided into many varieties, as Treadwell, Diehl, Clawson, Tappahannock, etc. In wheat *Triticum* there is but a single spikelet at each joint; its two glumes placed transversely, and it is from three to several flowered; the lower palet is pointed or furnished at the tips with awn, of variable length; stamens, three. The sub-divisions into Spring and Winter, seem to be the result of cultivation more than anything else, for several different experimenters have been able to produce the Winter variety from the Spring, after several successive trials, and the reverse is also true.

De Condolle—a botanist of high authority—believes wheat to be the result in growth of the cultivation of a wild grass. He even claims that this grass is still growing in certain localities in Central Europe. Many different varieties have been cultivated. One gentleman in France, who has experimented largely with this grain, has succeeded in raising 322 entirely different varieties. The differences between varieties consist in the size of the plant, its shape, habit of growth, in its foliage, in the size or shape of the spike or head, and in the size, form, color and heaviness of the grain. There are about twelve varieties in this country. The same variety is found in different localities under different names, so we have many purely local names. So a certain variety may grow luxuriantly in one locality, and be nearly, if not quite, a failure, in another, due to the soil, climate, and various other causes, singly or combined. But all farmers know that a good soil is as necessary for a good yield of wheat as for any other grain. Of course, pure, clean seed is a most indispensable aid to insure a fine crop, and plenty of skill should be exercised in keeping out all foreign seeds. The weeds which are the most troublesome to wheat are cockle, *hychnie githago*, and chess or cheat, *bromus secalinus*, which is sometimes so abundant that some farmers take it to be degenerate wheat. In New York a great deal of trouble is experienced from the presence of red-root or gromwell, *lithospernum averese*. Then wheat

is troubled with rust, smut, the weevil, the Hessian fly and wheat moth.

Wheat retains its vitality only from three to seven years, and the stories, so generally believed, of wheat being found in Egyptian mummies, thousands of years old, capable of growth, etc., are now discredited. It is believed the cunning Arabs hide these seeds there to deceive the unsuspecting and susceptible traveler, for very recently there have been found Indian corn, and dahlia tubers, exhibited by these sons of the desert as grains and roots which for centuries have been quietly sleeping, waiting only for moisture and sunlight to awaken them to life and growth. 'Tis fortunate for the happiness of our poor Arabs that they are entirely ignorant of the fact that Indian corn and dahlia tubers were not known until after the discovery of America.

Before we take up the minute structure of wheat itself, let us study the microscopic structure of the plant, for every part shows beauties under this aid to the eye, which, without it, would never be mistrusted to exist. Every part of the stem, the root, and head, and seed, would, of itself, form a study, but with limited time and space we can at most only hope to obtain a general idea of the minute structure of each part. Many interesting questions could be answered here, were we not intending only to give the microscopic structure, as: How does wheat grow? How does it assimilate the elements, even minerals, of the soil, transforming material so unlike itself and storing away its starch in the tip of the root at one end and in the center of the kernel at the other? How is moisture gathered from the soil and carried to the extreme end of the head? All these and similar questions are found well explained in our vegetable physiologies, and to these works are our readers referred, while we proceed to give the results of original work, commencing first with the structure of the straw or stem.

If we take a wheat straw that has been soaking in water for twenty-four or thirty-six hours, and with a very sharp razor make a cross section and examine under a microscope, magnifying from 75 to 100 diameters, we will be able to form a very correct idea of the structure of the stem. Only a part of such a section is shown in figure I. This being but a small segment of the circle, which, when completed, forms the entire circumference of the straw. The whole structure is made up of vegetable cells, only many are modi-

fied differently in order to fulfill some special object, for which they were made.

The principal framework of the straw is built up of such cells as appear at *D*, very thin walled and hexagonal. These cells are modified in shape as they approach both the inner and outer edge of the figure. At the inner edge we see regular four-sided, thin-walled cells; as they reach the outer edge we find the walls quite thick and the cells also four-sided. The row of cells as seen at *C*, form the epidermis of the straw, and is composed of a simple layer. The outer edge of these cells is quite thick-walled, and forms the cuticle. This cuticle is what gives the smooth polish to the surface

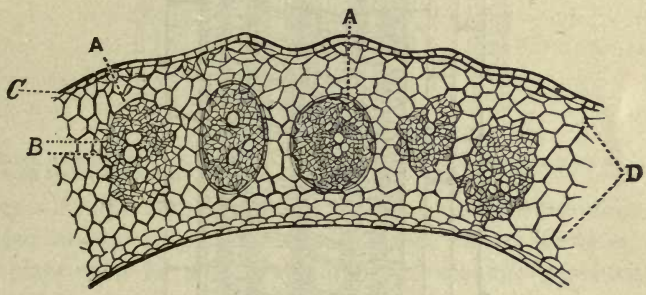


FIG 1. CROSS SECTION OF WHEAT STRAW.

A, Vascular Bundles. B, Spiral Vessels. Drawn with Camera Lucida, X 75.

of the straw. In some varieties of wheat this cuticle is much thicker than in others. If the season is a long, cold, stormy one, or if the wheat grows in a cold climate, the cuticle will be found to be thicker and more leathery. The darker round portions of the figure, as seen at *A*, are the woody portions of the straw, or, as they are called, fibro-vascular bundles. The fine cells forming the most of these bundles, are woody cells, while the large openings near the center of these bundles are the cross sections of large vessels or ducts that run the whole length of the straw.

Figure 2 represents a longitudinal section of a vascular bundle. The cells shown on either side of this bundle, at *C*, are the fundamental cells seen in cross section at *D*, Fig. 1. The cells at *B* are the woody portions seen at *A*, in Fig. 1. They have very peculiar little pitts covering their surface. The large vessels at *A*, Fig. 2,

are the same as those seen in the cross section at *B*, Fig. 1, only magnified many times more.

The spiral bands arranged so beautifully around these vessels are little fine tubes, coiled around on the inside of the large vessels, and growing firmly to the inside wall. Water or moisture is carried the length of the straw by this spiral tube, as well as being absorbed through the cell walls.

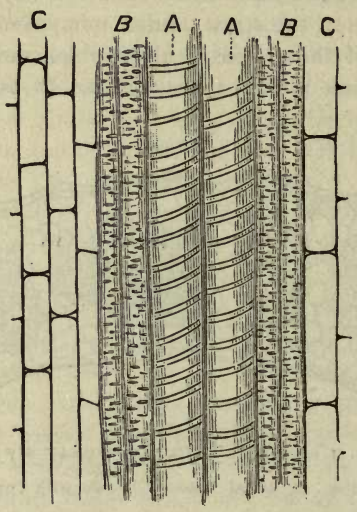


FIG. 2. LONGITUDINAL SECTION OF WHEAT STRAW.

Showing a Vascular Bundle. A, Spiral Vessels. B, Pitted Vessels. C, Regular Parenchymatous Cells. Drawn with Camera Lucida, X 375.

The only object of the woody portion of the straw is to give strength enough to the plant to hold up its head until the wheat is ready for the harvest. The spiral vessels and woody portions do not, as many suppose, carry *all* the sap through the plant. The sap is carried right through the cell walls by absorption, principally by those cells found at *C*, Fig. 2, and at *D*, Fig. 1. In order for the sap to be raised one inch, it is obliged to pass through over two thousand of these cells.

Fig. 3 shows the epidermis covering the outer surface of the straw. It has been torn off lengthways, and is the single layer of cells seen at *C*, Fig. 1. The long, narrow cells at *B* make up the

epidermis as it covers the vascular bundles or ridges found running lengthways of the straw. The larger cells, at *C*, are found covering the grooves seen in the depressions in Fig. 1 between the vascular

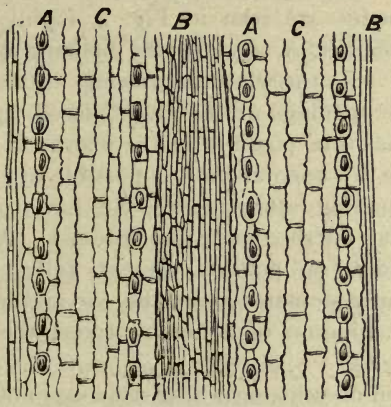


FIG. 3. EPIDERMIS OF WHEAT STRAW.

A, Rows of Stomates. B, Opposite, or over the Vascular Bundles seen at A, Fig. 1. Drawn with Camera Lucida, X 75.

bundles. At *A*, we find peculiarly modified cells surrounding openings that are the regular breathing places, called stomates. The wheat plant must be able to breathe, to exchange gases with the

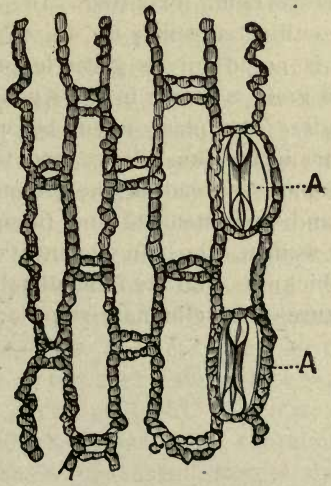


FIG. 4. EPIDERMIS OF WHEAT STRAW.

Same as Fig. 3, magnified more. A, Stomates or Breathing Places. Drawn with Camera Lucida, X 375.

surrounding air, to throw off a superfluous amount of moisture, or to absorb moisture from the atmosphere when the earth is too dry to supply its demands.

These stomates are seen in Fig. 4, highly magnified. The dark line at the center, *A*, is where the opening occurs, here represented as closed. As the wheat is growing in the field if a dry, hot day comes, these openings will be found closed tightly, in order to retain all the moisture possible in the plant. If the day is damp, the little mouths will open as wide as possible to exchange moisture with the surrounding atmosphere. We have proved this many times by careful microscopic examinations. Where this power of moving resides is not at present fully determined, but true it is these little stomates guard the life and habits of this plant as closely as the windows of a house protect the inside from the storm.

The question of utilizing wheat straw has not been acted upon to any great extent by our American farmers. In some countries it is considered of great commercial value. In Ecuador the most of the native women and children are employed in picking and sorting straws for market. Large quantities are imported to America to be made up into straw work, but the most of it is made up into hats and fancy work before being exported. In Tuscany a peculiar variety of wheat is cultivated, solely for its straw, known as *Triticum tungidum.* It is noted for its great length, slenderness and strength. The seed grain is grown in the Apennines and the straw crop on the low lands. The plant is cut before maturity and left on the ground to dry in the sun. It is then tied in bundles and stalked. It is afterwards spread on the ground to be bleached by the sun and dew, and then steamed and fumigated with sulphur. They are sorted by women, who can instantly detect the slightest difference in their thickness, and are immediately plated, for, owing to their flexible nature, no preliminary steps are necessary to this process.

THE MICROSCOPICAL STRUCTURE

OF THE DIFFERENT COATS.

WOULD you believe there was any great complexity in the structure of a grain of wheat in looking at it with the naked eye?—for certainly it looks like the most simple thing in the world. Yet that very little grain possesses a mechanism even more complicated and curious than the structure of the most elaborate machinery. It would be impossible to produce it artificially. No mechanical work would be able to produce the delicate tracings or the minute cell divisions which the microscope shows to be so beautiful. Neither could it produce the nearly transparent covering, so delicate, so thin, and yet so strong and tough, as to bravely withstand the effects of moisture. That the wheat is minute as well as intricate in its structure, we shall see before we are through with this study.

A grain of wheat is oval or egg-shaped, with a deep longitudinal furrow on the inner face; with a keel or irregularly curved surface covering the embryo on the back near the base of the grain, and with quite a heavy growth of vegetable hairs at the opposite end or the apex. It must be remembered that a grain of wheat is not a seed as so many think, but rather a perfect fruit enclosing the seed within itself, so necessarily its structure is more complex. Starting from the outside of the kernel, let us see what different structures we find before reaching the center. First, there are three fruit coats known as the first, second and third fruit-coats, then there are two seed-coats known as the first and second seed-coats. This makes five distinct coats surrounding a grain of wheat, which, taken all together, have a thickness of less that 1–15 of a millimeter (1–400 of an inch). Then we come to a coat as thick or thicker than these five coats, containing the nitrogenous substances. Then the whole central mass of the grain loaded with starch, and last the embryo at the base. It may make this clearer if the different parts are tabulated as follows:

FRUIT-COATS OR PERICARP.	1. Outer fruit-coat, or epidermis, or EXOCARP. 2. Middle fruit-coat, or MESOCARP. 3. Inner fruit-coat, or ENDOCARP. 4. Vascular bundle.
SEED-COATS.	5. Outer seed-coat, or TESTA. 6. Inner seed-coat, or ENDOPLEURA.
ALBUMEN.	7. A single layer of large cells filled with gluten and nitrogenous products—PERISPERM. 8. Large hexagonal cells filling the central part of the grain and loaded with starch, etc.—ENDOSPERM.
EMBRYO.	9. A single layer of empty compressed cells. 10. Regular hexagonal cells of the embryo filled with starch, oil, etc.

As we understand the term "bran," it includes the first seven of these parts, that is, all of the different coats of the wheat.

1. The outer fruit-coat, or the epidermis, consists of a single layer of cells—see Fig. 1.—similar in appearance to those found in the epidermis of the straw,—long, narrow cells with a strong cell-wall, looking something like a string of beads. An important thing to remember is that the longest way of the cells is with the length of the grain. About the center, that is, midway between the two ends on the surface, these cells are in length nearly three times the width, while as they approach either end they gradually grow shorter and rounder. Occasionally stomates are found in the epidermis, but not regularly as in the straw. At the apex of the grain,

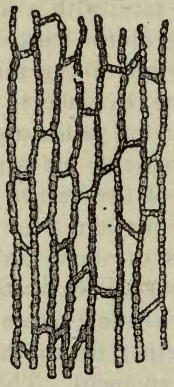


Fig. 1. Epidermis or First Fruit-coat of Wheat. X 75.

and growing out from this layer of cells, are the long slender hairs seen in Fig. 2; "A" shows the epidermis and the way the hairs are embedded in the cells. These hairs are composed of a single cell

with very thin cell-walls which leave quite a cavity in the center as seen at "B." This cavity in all probability is filled with gas of some kind, and if we estimate several hundred of these hairs on each grain of wheat, which is by no means too large an estimate, would it not be right to wonder if the breaking up of these hairs and the escaping of the gas might not be sufficient to explain some of the mill explosions of the present time? With this thought in mind we obtained a short time since some of the dressings left after the flour had passed through a middlings purifier, and were surprised to find such a large per cent. of the mass to consist of these

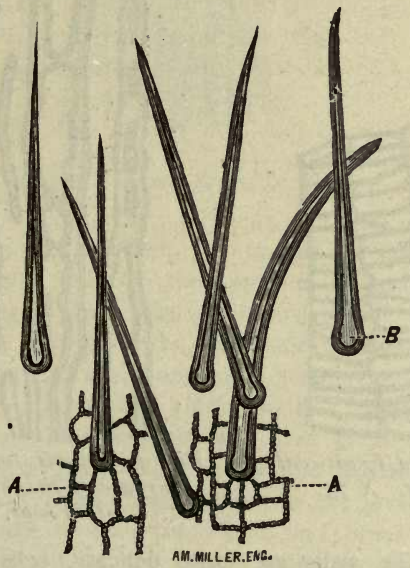


Fig. 2. Hairs found at the end of a Wheat Kernel. X 75.

hairs. Nearly half of the entire quantity was composed of these fine, delicate hairs, that are so light and inflammable. Chemistry teaches us that almost any dry material when powdered and mixed with air in just the right proportion, will explode if a flame is brought near. Now these hairs are so light and dry that they float in the air easily, and they burn very readily when thrown into the air over a gas-jet. If chance has mixed this dry powder at just the right proportion with air for an explosion, and if chance has

brought a lighted lantern or a flame of any kind in contact with the mixture, who can say what would be the result?

Certainly the subject is well worth experimenting with, and the miller is in a much better position to do this than the scientist, for he is acquainted with all the practical workings of the mill, and familiar with all the questions of mill explosions.

2. The middle fruit-coat, or *mesocarp* as called by botanists—is made up of several layers of longitudinally extended cells, similar in appearance to the first coat, only not beaded

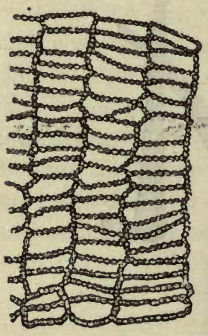


Fig. 3. Third Fruit-coat of Wheat. X 75.

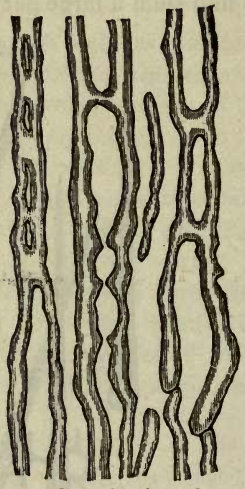


Fig. 4. Canals found on the inner surface of the third fruit-coat of Wheat. X 375.

so strongly. The walls are more delicate, cells a trifle wider and closely adherent to each other and to the epidermis. It is almost impossible to separate these two coats without the aid of re-agents.

3. The inner fruit-coat or *endocarp* is composed of long, narrow cells similar to those of the first coat, only lying at right angles to them, that is, the longest way of the cells lies cross-ways of the grain. (See Fig. 3.) They are from 1-150 to 1-300 of an inch in length. The walls are more finely beaded, presenting a stronger appearance than in the outer fruit-coat. It is almost impossible to mistake any of these coats

under a microscope, or even to get them confused, for they are generally together, and are always the same, whether you find them in flour, in studying the structure of the grain, or, as is too often the case, when we find them where wheat has been used as an adulteration of some ground spice or drug.

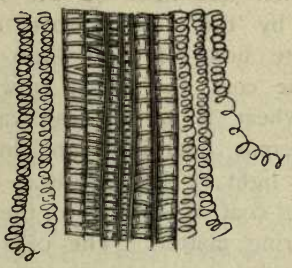


Fig. 5. Spiral Vessels found in Wheat. X 400.

The three coats lie together, but in one direction we see only one layer of cells, while in the opposite we find three or more. The single layer is the third fruit-coat, while the others are the second and first. On the underside of this fruit-coat, and attached firmly to it, are found very peculiar canals, frequently anastomosing, and having thick walls. They run lengthwise of the grain, and in this way give great strength to the fruit-coats. (See Fig. 4.) What remarkable provisions for strength we see in the way these three fruit-coats are arranged.

4. If you take a grain of wheat and break it open longitudinally, breaking it in the crease made by the deep groove, and examine the edges of the epidermis as they fold over in this groove, you will find a line of a deeper color than the rest of the wheat grain. If this dark line be taken out and treated with potassic hydrate and examined under the microacope, s delicate vascular bundle will be seen. (See Fig. 5.) Another sign of strength in the grain. The spiral vessels are seen plainly as they uncoil under the action of the re-agent, as shown on either side of the figure. This vascular bundle is seen plainer near the center of the grain than at either end.

5. We have divested our grain of its fruit-coats, and have

now nothing except the seed left. There are two seed-coats, made up of long, slender cells, with very thin, nearly transparent cell walls, the cells of two coats cross each other at right angles. The outer seed-coat or *testa* is the coat which furnishes the coloring matter, and decides whether the grain shall be red, yellow, or white. The coloring matter exists in little roundish masses, seen in greater quantities on the surface of the grain which is protected by the deep groove, or near a vascular bundle. If there are none of these little masses of coloring matter present in the coat, the wheat is white, if there is a great quantity the wheat is of the red variety; and between these come the different quantities, and in proportion to the amount, the wheat is light or dark yellow.

6. The second seed-coat is similar to the first, only wanting the pigment or coloring matter. The cells of both coats are collapsed and hard to demonstrate, and not of sufficient importance to illustrate.

Thinking some of our readers might like to make some of these examinations themselves, we give some of the details of the work.

Let the grains soak in warm water for about twelve hours, then hold a grain on the end of a needle which has been wedged into a wooden handle, and with another needle pick off carefully the outer fruit-coat and examine with a microscope. It is so coarse as to be seen readily with a magnifying power of fifty diameters. After this it should be examined with a higher magnifying power in order to see the beaded structure. After removing carefully the epidermis place the grains back in the water and allow them to soak from twelve to twenty-four hours longer. The second and third fruit-coats can now be examined. If these are picked off carefully and the grain allowed to soak a few hours longer, the remaining structures can be separated and examined.

THE COATING AND CELLULAR STRUCTURE

OF THE WHEAT BERRY.

7. WE have disposed now of the woody part of the grain, and have just reached the layer of cells, which is possibly of the most interest to millers. A layer of large, nearly square cells, with very thick walls and filled with fine granular matter, see Fig. 1. The cells are 1-20 of a millimeter (1-500 of an inch) in diameter, and quite uniform in size. The cell walls are composed of several layers of cellulose, presenting somewhat a laminated appearance under the microscope. These layers can be separated from each other quite distinctly by boiling in water for several hours or in a solution of caustic potash for a short time. The granular contents are enclosed in sacks, which are embedded in the cellular walls, as seen in Fig. 3, where the two sacks have floated out of their usual resting place. These sacks contain nitrogenous substances, and contain them in much larger proportions than any other part of the grain. If any means could be employed by which the grain could be divested of all its coats excepting this last, and this last coat could be treated in such a way as to separate the nitrogenous sacks from the framework holding them, and then have the sacks form a part of the flour, we would probably have the finest and purest flour possible. The process of scientific milling has made such great advance during the past twenty-five years, who can say but ere the next twenty-five years pass, we shall have these microscopical sacks of nutrition separated out from the woody part of the grain. The gluten, or nitrogenous substances, exist in very minute particles, about 1–600 of a millimeter (1–15000 of an inch) in diameter. They are insoluble in water, alcohol and glycerine, and are not affected by iodine or potassa. Ammonio-nitrate of silver turns them a dull yellow, while a solution of carmine turns them a

bright yellow. Nitrogen is found only in cell-contents, and is never found in cell-walls.

8. Inside of the layer of albumen is found only one structure until we reach the embryo, at the base of the grain. It is composed of large, thin-walled hexagonal cells, loaded with starch, see Fig. 2. To see these cells plainly under the microscope a very thin section must be cut from the central part of the grain with a razor, or a sharp knife, and then washed off carefully with a camels-hair brush, so as to remove the

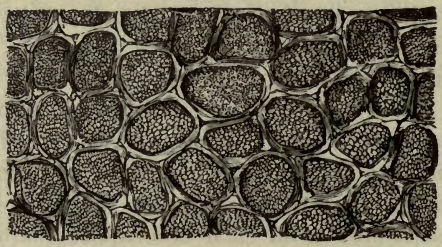


Fig. 1. Outer Layer of Albumen. X 200.

grains of starch, when we find a delicate white structure resembling a honey-comb in all except color. At the center of the grain the cells are the largest, and are quite uniform in shape and size, measuring nearly 1–10 of a millimeter (1-250 of an inch) in diameter. At the surface of the albumen the cells are quite long and narrow, and lying in such a way that they appear to radiate from the center toward the surface. The walls are delicate and nearly transparent, showing under a high magnifying power the different structures or layers of cellulose. The cells are loaded with starch grains, as seen at *a*, Fig. 2.

9. Just inside the hexagonal cells, which fill the inside of the grain, and at the same time surrounding the embryo, is found a single row of empty compressed cells, quite difficult to demonstrate.

10. The embryo occupies the lower end of the grain, and is a small oval body about one millimeter in width and two in length. The main object in life for the wheat is the production of this embryo. The development of the stem, the branching and expanding of the leaves, the whole life and his-

tory of the blossoms, is for the development of the life-germ contained within the embryo, and when this is produced the whole plant dies. The hard coats we have already described are made only to protect the starch and albumen of the center, and to give warmth to the embryo, while the starch and albumen, which are stored away in such profusion in the grain, are only formed to give nourishment to the germ while it

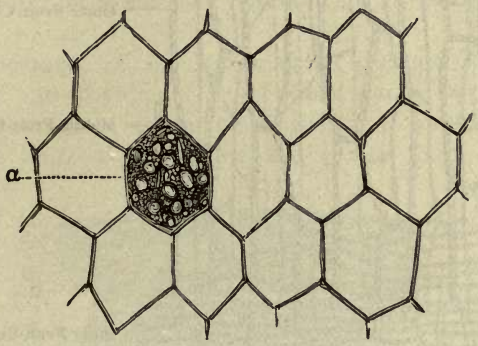


Fig. 2. Hexagonal Cells from the Central Part of a Grain of Wheat. a, shows a Cell filled with Starch Grains. X 100.

grows. The structure of the embryo will form a study by itself, as it is very complicated, containing within itself all the parts of the new plant, which it will produce when placed under favorable circumstances.

Fig. 3 gives a diagramatic view of the "bran" of wheat, or of all the different coats, and of the outer layer of cells containing the albumen and gluten. Any of my readers who have examined the wheat with the microscope know how difficult it is to separate the first and second fruit-coats. They almost always are seen together, as in the figure, while very generally the round cells of the albumen are seen together with the different fruit-coats, particularly with the inner fruit-coat. When the outer fruit-coat is examined with the microscope, and is in focus, the middle coat is not seen distinctly; occasionally is caught a glimpse of the beaded structure. Very frequently the three fruit-coats are together, as in the figure. Just beneath the third fruit-coat are seen the canals. The two seed-coats seen just below the canals, and at the lower right-hand corner of the

figure, show as distinctly as they are generally seen. Frequently there is no appearance of cell structure in either of these coats. Immediately below the two seed-coats is found the outer layer of albumen, seen at the lower left-hand corner of the figure. By the openings around the edge of the layer, we see that the

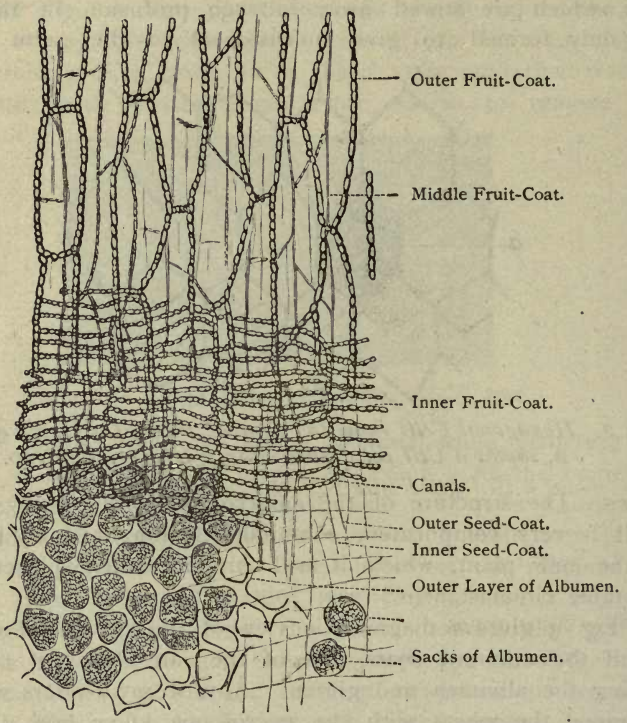


Fig. 3. Showing the Different Coats of Wheat.

granular matter is contained in sacks. Two of the sacks have floated out and are seen as distinct from the coat.

In Fig. 4 we have a cross section of a grain of wheat, shaved off nearly midway between the ends. At *A*, is seen a thickening of the outer fruit-coat, which is given for extra protection to the grain. At *B.* are seen the openings formed by the cells of the first fruit-coat. They are much larger in some varieties than the cells of the second fruit-coat, as seen at *C.* The peculiar beaded structure of the third fruit-coat is

seen at *D*. It must be remembered these cells run around the grain, while in the first and second coats the cells run lengthwise. At *E*, are seen the two seed-coats. Here again there is a slight thickening of the outer cell-walls. The masses of coloring matter are located in the outer layer of *E*, and are seen as little dark crystals. At *F*, is seen the outer layer of albumen, quite large cells, arranged perpendicular to the surface. Inside of all come the regular cells of the center, filled with starch.

The appearance of the starch under the microscope is very characteristic and peculiar. Pure wheat starch can be obtained by cutting through a grain of wheat and scraping with the point of the knife a little from the central part of the grain

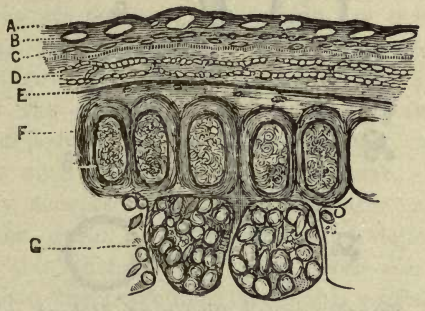


Fig. 4. Cross Section of Wheat. Drawn with Camera Lucida. X 200.

on a glass slide. By placing a drop of water on the specimen and examining it then with a microscope we are prepared to study its appearance. There are two distinct kinds of starch grains floating in the field; small, spherical or angular starch grains collecting frequently in masses, many times more numerous than the large grains, about 1–200 of a millimeter, (1–5000 of an inch) in diameter. The others are large lenticular grains, which when viewed on the face, appear like a spherical body, but when viewed on the edge, appear like a double-convex lens, see Fig. 5. This lens shape can easily be proved by touching the cover-glass gently while under the microscope, with a pencil point, and watching the grains roll over in the field, presenting alternately the appearance of a sphere and a lens. This simple test should always be used when

working out the adulterations of any flour or spice. There is seldom any nucleus present; when it is present though, it will be found near the center of the starch grain. Still more seldom are there any rings present. According to Dr. Julius Wiesner, Professor in the University of Vienna, there is to be found still a third kind of starch grains in wheat; a compound grain found in the interior of the outer layer of albumen, and made up of from two to twenty-five individual granules. These compound grains are very seldom found in either the flour or in commercial wheat starch. Occasionally broken pieces of the compound grains are found, but these are about all the indications of a compound grain we see. They are ellip-

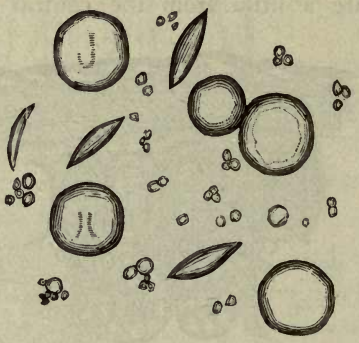


Fig. 5. Starch from a Grain of Wheat. X 375.

tical or egg-shaped and frequently much larger than the lenticular grains. When subjected to dry heat, the grains of wheat starch are changed very much in appearance, being warped considerably from their normal shape. They are larger, more brittle and more transparent. However, they generally can be identified, when subjected to either dry or moist heat—if the moist heat be not raised to boiling-point, which would change it to a gelatinous mass. The large grains of wheat starch in their natural or normal state are very uniform in size for the same variey of wheat, but the starch grains found in the different varieties of wheat differ considerably in size. The average size is about 1–40 of a millimeter (1–1000 of an inch) in diameter. The theory of the growth and formation of these starches is of considerable interest.

Starch is the most generally diffused, excepting protoplasm, of all vegetable substance within the cell-wall. When found in the older structures, roots, stems, seeds, etc., it is found nearly pure; when found in freshly growing tissue it is in union with chlorophyll. Starch grains contain carbon, oxygen, hydrogen, and some mineral matter. They are insoluble in water, alcohol, ether and oil, are destroyed by potassa, and colored blue or violet by iodine, the color depending on the density of the granule and the strength of the iodine. The starch grains of different families and different species of the same family differ so much in size and general appearance as to be easily identified. The largest starch grains known are those of the *tous-les-mois* which are frequently 1–12 of a millimeter (1–300 of an inch) in diameter, while the smallest of the commercial starches are those of rice, which are occasionally 1–280 of a millimeter (1–7000 of an inch) in diameter. There are two leading theories regarding their growth. Some claim that the surface of the grain is first formed, and that it grows by layers, being deposited on the inside of the case, which gradually expands until it reaches its normal size. The other and more generally accepted opinion is, that the nucleus is first formed, and the grain grows by means of deposits of starchy matter around this nucleus, and each successive layer contains less moisture than the preceding layer; this explains the appearance of rings or laminæ seen occasionally in the wheat starch, but showing so plainly in the potato starch and many others. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain, and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. In very many starches there is a distinct dark cross seen when viewed with polarized light, the arms of the cross radiating from the nucleus. Some botanists claim that a cross can be seen in wheat starch, but if this be true, it is different for the starch of the different varieties of wheat. In some grains of wheat starch there is no appearance of a cross, while in some others there is a faint shadow crossing the grain while polarized light is being used.

VARIETIES OF WHEAT.

THE peculiarities of a vegetable growth are transmitted from one generation to another; that is, plant characters are hereditary. There are certain characteristics of every species which are produced in generation after generation of the plant, while frequently peculiarities will be possessed by an offspring which were not found in the parent plant. Occasionally these distinctive peculiarities or characters will belong only to the individual plant, while in other cases they will be produced in their descendants, and become hereditary. When a new property or character is transmitted by inheritance to new generations, so as even frequently to become as constant as the primative form, we have what is known as a new variety. *Varieties* are constant forms of new characteristics.

There is a great difference in plants in their tendency to produce varieties. Some plants seem to have no disposition to variation, but are distinguished by the consistency of their characters, as, for example, rye, which has as yet produced no hereditary variety, notwithstanding long cultivation, while, on the other hand, some plants seem to have the greatest proclivity for change. The same parent plant may produce numerous varieties; as, for instance, our common garden dahlia, with its hundreds of different forms, have all come from the simple yellow blossom, which was cultivated for the first time in 1802. And the almost innumerable varieties of pansies, distinguished chiefly by the color of their flowers, are all cultivated from the common, wild violet, while almost as numerous are the varieties produced from our common field pumpkin—*Cucurbita pepo*—from which have been produced all the varieties of water melons, gourds, musk-melons, squashes, cucumbers, etc. The character of many of these varieties seems to

be perfectly hereditary, and all the organs show the greatest degree of variation. The fruit of one variety is more than 2,000 times the size of the fruit of another variety. The varieties of melon differ very much, some being as small as plums, while others weigh as much as 66 pounds; one variety has a scarlet fruit; another is only an inch in diameter, but is three feet long, and is coiled in a serpentine manner in all directions; the fruit of one variety can scarcely be distinguished externally from cucumbers; one Algerian variety suddenly splits up into sections when ripe. The cultivated varieties of corn are descended from a single primitive wild form, which has been cultivated in America for a long period. There is at present a very wide difference between the cultivated varieties and the primitive one, as well as a very great difference between the cultivated varieties. Some of the plants are only one and one-half feet high, while others are from fifteen to eighteen feet. The grains vary extremely in form, size and number, while in color they vary from white, yellow, red, orange, violet, streaked with black, blue, or copper-red. There is even one variety of corn which has three different

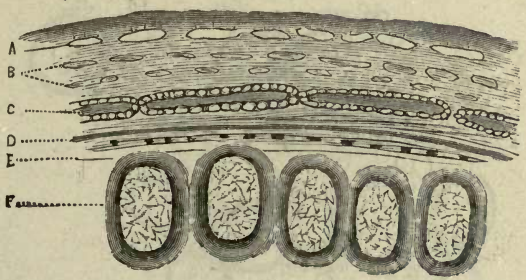


Fig. 1. Cross Section of Diehl Wheat. X 250.

A, First Fruit Coat; B, Second Fruit Coat; C, Third Fruit Coat; D, First Seed Coat; E, Second Seed Coat; F, Albuminous Layer. Drawn with the Camera Lucida.

kinds of fruit, differing in form, color and size, on one ear. These illustrations are used only to show to what extent the amount of deviation in the varieties of a primative form may increase under cultivation. Wheat gives us just as fine an illustration of the great variation in a vegetable form as any of those already mentioned. The three different spec

of wheat known as *Triticum vulgare*, *Amyleum*, and *Spelta* seem to be the most prolific in producing varieties, for from these three seem to spring an ever increasing number. The char-

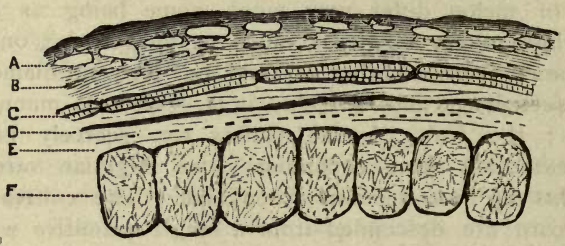


Fig. 2. Cross Section of Clawson Wheat. X 250.

A, First Fruit Coat; B, Second Fruit Coat; C, Third Fruit Coat; D, First Seed Coat; E, Second Seed Coat; F, Albuminous Layer. Drawn with the Camera Lucida.

acters of the cultivated varieties of one parent-plant shows, according to Darwin, a constant, striking and remarkable relation to the purpose for which the plant was cultivated by man. The varieties of wheat differ from each other only slightly in the size of the stalk, or in the form of the leaf,

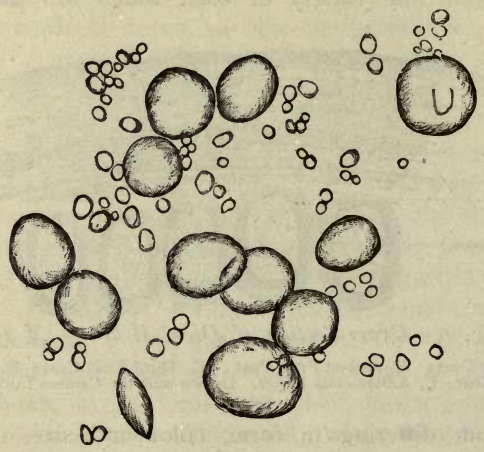


Fig. 3. Starch Grains of Diehl Wheat, or Diehl Flour. Drawn with Camera Lucida. X 475.

which are of little importance to mankind; but they show a great variety and extent of difference in the form and size of

the grains, and in the amount of starch and proteine contained in them. In other words, the greatest characteristics are found in those parts of the plant for the sake of which it is cultivated and in those properties of these parts which, under various circumstances, are especially useful to mankind.

The causes producing variation in the vegetable forms are yet under discussion by botanists, although some of them are settled beyond a doubt. One general occasion for the appearance of new individuals, differing from the old stock, is the fertilization of the known species, by the pollen-grains of some strange variety. These pollen-grains may come from some wild specimen growing in the adjoining woods, or even from the wheat-fields of some neighboring State. The wheat-fields need not lie adjoining each other in order that the one may fertilize the other, for the pollen-grains are so very minute the wind might carry millions of them immediately in front of our

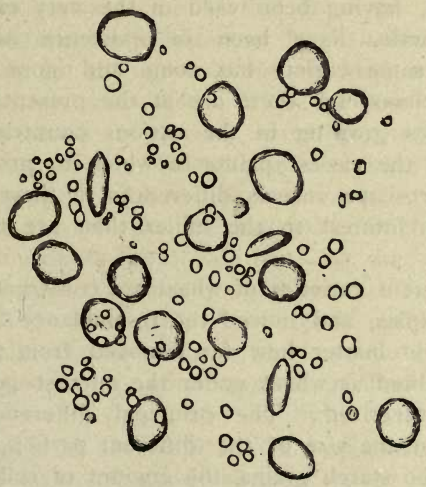


Fig. 4. Starch Grains of Clawson Wheat, or Clawson Flour. Drawn with the Camera Lucida. X 475.

eyes, yet we could not see that the air was darkened in the least by their presence. They are so light they can easily be carried miles by the air before they are dropped. Sometimes it happens that a single bud or blossom, for some unaccountable reason, will develop differently from all the other buds

of the plant. This single individual would, in several years, produce quite a growth. Then there are changes produced in a plant by the nature of its food and other external conditions. Specimens of the same kind will differ very conspicuously in the size and number of their leaves, flowers and fruits, according as their supply of food has been abundant or deficient. Deep shade frequently produces the most striking change in the habits of wheat when they are accustomed to grow in the sunlight, as all farmers can testify. These practical questions are studied carefully by farmers whenever they wish to produce any particular variety of wheat.

Unfortunately, it is not known to what country we are indebted for the primitive plant of wheat. One of the greatest botanists (De Candolle) claims that the original grass from which wheat has been produced is yet growing in some obscure locality in Central Europe. However, it is the oldest cereal known, having been used in the very earliest time. So probably varieties have been in existence and disappeared. Perhaps the same variety has come and gone on the world's stage many times, for there are at the present time many different varieties growing in the various countries of the world. It is one of the easiest plants in which to produce variations.

The microscope reveals differences in these varieties, which are of more interest to the miller than are the physical appearances.

The different varieties of wheat are constructed on the same general principles, and indeed the resemblance is so strong that any variety, no matter how far removed from the typical form, can be identified as wheat under the microscope, however finely it may be pulverized. The principal difference between the varieties is in the size of the different parts; as, for example, the size of the starch grains, the amount of cellulose packed on the cell-walls, or the thickness of the different coats. The examination and the measurements for this work have been made with considerable care, while the illustrations are all drawn with the camera lucida, so there can be no chance for the author's imagination to play any part in the drawings. (A camera lucida is an instrument which, by means of a prism or glass set at a certain angle, the image of the object in the microscope may

be thrown on the drawing-paper, and there traced accurately with the pencil.) The following are the varieties which have been examined: Diehl, Treadwell, Tappahannock, Wicks, Egyptian, Schaffer, Russian and Clawson. The largest and coarsest structure of all was found in the Diehl wheat, although the Treadwell was so nearly the same that it would be almost impossible to separate them, while the smallest measurements were found in the Clawson. All of the other varieties fell between these two extremes, and in about the order named. Figures 1 and 2 give cross sections of Diehl and Clawson wheat. These sections were cut from as near the center of the grain as possible. At *a*, *b* and *c* are seen the fruit-coats; but see what a difference there is between the two specimens. The fruit-coats of Diehl are so coarse and thick, as compared with the corresponding ones of Clawson wheat. The same difference can be seen in the two seed-coats *d* and *e*, while the greatest difference of all seems to be in the immense, great walls of the cells constituting the albuminous layer. There appears to be no deficiency in the growth of cellulose, when Diehl or Treadwell wheat are cultivated. This cellulose is what composes the great mass of woody structure, and is just as easily digested as wood. This albuminous layer furnishes the largest proportion of nitrogenous substances. Any one can readily see that the thicker the cell-wall for the same width cells, the less nutrition there will be. So the amount of nitrogenous substances contained within the cell-walls of Diehl wheat is not as great in proportion to the size of the whole cell as the amount contained in the corresponding cells of Clawson. All of the structure which appears in these cross sections properly belong to the bran, and hardly form a part of flour. If it were possible to secure all the nitrogenous substances out of their native layer, *f*, allowing them to be a part of the flour, and discard the rest of the structure belonging to the different coats, you would have the most nutritious and the very best quality of flour.

The flour produced from these varieties of wheat is probably of greater interest to millers than the bran. In the case of the flour, as well as the structure, Diehl and Clawson are the two extremes, while the other kinds are found somewhere

between them. See Figures 8 and 9. The greatest difference is found in the size of the large grains of starch, those of Diehl being $\frac{1}{816}$ of an inch in diameter, while in Clawson they are only $\frac{1}{1266}$ of an inch in diameter; Treadwell, $\frac{1}{860}$; Wicks $\frac{1}{881}$; Egyptian, $\frac{1}{994}$; Scaffer, $\frac{1}{1000}$; Russian, $\frac{1}{1174}$. Although the difference is nowhere near as marked in the small grains, still there is considerable difference in their size. Schaffer, $\frac{1}{4700}$ of an inch in diameter; Treadwell, $\frac{1}{6100}$; Russian, $\frac{1}{4000}$; Egyptian, $\frac{1}{6000}$. These measurements were obtained by taking a large number of as nearly typical grains as possible, measuring them accurately, and then obtaining their average diameters.

Adulterations of Wheat Flour.

It is not the aim of these articles to give information that will enable a miller to sell, at first class prices, a quality of flour that ought never to be sold; nor is it to show how dark, musty flour may be rendered so white as to deceive the public; nor to prove how wicked it is to sell substances unwholesome or injurious to health under the name of wheat flour. But the aim is to show how easily any foreign substance in flour may be detected. The miller who prides himself on the secrecy with which he, in the dark recesses of his mill, grinds up different substances to mix with wheat, little dreams that it is impossible for him to powder them so fine that they cannot be seen under a microscope. There is nothing used to any great extent, either as a substitute or an adulteration of wheat flour, that has not been detected by either the microscopist or the chemist. And any miller, with a slight expense to himself of time and money, may learn to detect foreign substances, if present, in any specimen of wheat flour that comes to his notice. A microscope, some published illustrations of the different ingredients that one meets, together with a few weeks of practice, will be all that he needs. There are a few chemical substances whose presence can not be detected by means of the microscope. Chemical tests have to be called into requisition to discover these. Mineral ingredients have been reported many times, by foreign writers, as forming a part of flour, but these substances have never been reported, to my knowledge, as an adulteration used by any American miller. Their detection will be spoken of in the proper place. We have to deal now only with the simple forms that are found so readily with the microscope.

As these articles are to instruct, and not to please, I will digress long enough to say a word about the choice of the microscope necessary for such work. Any cheap, simple stand

—and there are so many in market, it will not be necessary to give the name of any particular maker—a ¼-inch objective, with a "C" eye-piece, that will give a magnifying power of from 350 to 500 diameters, will be needed. The whole may be obtained for $25, or possibly less. As a rule for simple work in microscopy, a stand with the least mechanism and the fewest adjustments is the one which can be worked with the most satisfaction. It would be very advisable to have a low power for work some of the time, either a 1-inch or a ½-inch objective. Unfortunately for those who attempt to accomplish this work by themselves, there are very few published illustrations on the subject which will help them. Many articles have been written, telling what is occasionally seen in wheat flour that does not belong there, and how it is to be found, but they give the reader little idea of how the substance looks or how it is to be identified. The surest means of identification is by close comparison with published illustrations, that have the merit of being somewhat accurate. In selecting a microscope, one should be obtained having such a combination of objective and eye-piece as will magnify the same as does the microscope from which the illustrations were made that you use for your guide. If, for instance, your microscope magnifies 800 diameters, and the illustration with which you compare your specimen was magnified only 100 diameters, you would see little resemblance between the two.

Flour is subject to adulterations of two kinds, which consist in the addition of mineral or of vegetable substances, and there seems to be two objects to accomplish by this addition. By mixing materials of a cheaper or poorer quality, the weight and bulk of the flour will be increased, or, by adding some ingredient to flour of an inferior quality, it is rendered white enough to pass for the best quality.

The following list of adulterations is given by different authors as having been found in wheat flour: Those used to increase bulk or weight are; corn, potatoes, beans, peas, oats, barley, buckwheat, rice, clay, bone-dust, gypsum and water. While those used to give whiteness are; alum, white-lead, lime, white clay, arsenic, plaster and chalk. Fortunately for Ameri-

cans, the most of these substances are reported by foreigners, for our American flours seem to be remarkably free from adulterations, as compared with those of the old country. In England, France and Germany, legislation on this subject has been very rigid. So the subject has been more carefully studied there than elsewhere. The millers and bakers of those countries seem to possess no conscience whatever, and had for years, before the government took hold of the subject, been in the habit of selling to the public, under the name of wheat flour,

Fig. 2. Potato Starch. Drawn with the Camera Lucida. Magnified 475 diameters.

anything whatever, without regard to its action on health. Some little time ago, in examining a suspected mill in England, 600 pounds of alum were found. Fortunately, the English people were saved from this inviting diet.

Adulterations occur more generally when the harvest is poor and grain is expensive. But it is a most remarkable fact that the very weather which will spoil wheat crops is the best weather to produce potatoes, so the first ingredient seized upon by millers to mix with wheat seems to be potato flour.

We have now some wheat flour, in which we suspect is potato starch or something else of a foreign nature. We will take up a little of the flour on the point of the penknife, placing it in a drop of water which has previously been placed on the glass slide and carefully covering it with the thin cover glass, when it is ready to study under the microscope. Examining some of the flour taken from several different parts of the specimen will generally be sufficient. This is the simplest and most convenient method of work, and does away with the long preparation, in which so many seem to delight. However, if very critical study of a specimen of flour be desired, perhaps the best method is that given by M. Boland, *American Miller*, August, 1878, page 183. Take a small amount of flour and add to it half its weight of water, to make a paste. Work this paste in the hollow of the hand, plunging it from time to time in a basin half full of water, slightly warmed. When lumps are no longer felt in the dough, wash the membraneous substance which remains in the hand under a stream of water, and when the water escapes clear the pure gluten is obtained. If there be any doubt of this, you have only to touch it with an alcoholic solution of iodine, and if it turns blue at the point of contact, starch is yet present; if it shows only a yellow color, you may be satisfied of its purity. Take the water used in washing the gluten, at the bottom of which a solid deposit has already been formed, and agitate it in order to place all the particles in solution again. Then pour it over a metal sieve into a conical-shaped glass vessel. Let the water which the vessel contains stand an hour. A deposit will then have formed in the bottom which must not be disturbed. Remove the water from this deposit with a siphon, and two hours later draw off the water again, which is still produced from the mass from time to time, until only a deposit remains, composed of two distinct layers. The upper one will have a grayish color, and is composed of gluten, of albumen, and of a sugary substance. The other layer will have a dull, white color, and is starch. Some time afterward carefully remove the upper layer with a teaspoon and allow the lower one to dry. The drying process may be facilitated by placing bits of blotting paper on the starch. When it is dry the starch

should be detached from the vessel, so as to preserve its conical shape. This little mass contains only starch, unless mineral or other adulterations be present. If it be all wheat starch, there will be no difference under the microscope between the specimens taken from the top of the cone or from the base. But if there be adulterations present they will consist of different weights and density, and they will be found in distinct layers parallel with the base of the cone. So the greatest care should be exercised in examining these different layers. If mineral substances be present they are found at the very tip of the cone, while in the layer next will be found the heaviest vegetable, which is probably potato flour.

In order to understand the difference between wheat and other starches, let us look again at wheat starch. There are two distinct kinds of starch grains found here; small, spherical or angular grains, collecting frequently in masses, many times more numerous than the large grains, about $\frac{1}{5000}$ of an inch in diameter. The others are large lenticular grains, which, when viewed on the face, appear like a spherical body, but when viewed on the edge, are like a double convex lens in shape. They are just like two saucers, set with their faces together. This lens shape can easily be proved by touching the cover-glass gently, while under the microscope, with a pencil point, and watching the grains roll over in the field, presenting first the appearance of a sphere and then a lens. This simple test should always be used when working out the adulterations of any flour or spice. There is seldom any nucleus present, when it is present though it will be found near the center of the starch grain. Still more seldom are there any rings to be found. According to one writer, Dr. Julius Wiesner, Professor in the University of Vienna, there is a compound starch grain present in the central part of the outer layer of albumen and made up of from two to twenty-five individual granules. These compound grains are very seldom found in either the flour or in the commercial wheat starch. When found they are elliptical or egg-shaped, and frequently much larger than the lenticular grains. The large starch grains of wheat in their natural or normal state are very uniform in size for the same variety of wheat, but the

grains found in the different varieties of wheat differ considerably in size. The average size is about $\frac{1}{1000}$ of an inch in diameter. Now if the specimen of flour be pure, we will have only these grains, together with minute particles of nitrogenous substances and occasionally broken fragments of the structure of the wheat. All of which are represented by illustrations in the *American Miller* of April, 1880.

Potato Flour.—See figure 2.—If it be not convenient to obtain the commercial starch, the fresh starch grains can easily be obtained by cutting a potato with a clean knife, and then floating on the glass slide, with a drop of water, the white substance which adheres to the side of the knife, and this will be the object desired. Or you may shave off a very thin section of the potato and place it in a watch crystal in a little water; the fine sediment settling to the bottom will be the starch. The grains are round, irregularly oval, or egg-shaped, and nearly transparent. The nucleus is not in the center of the grain, but generally quite near the smaller end, and it is always surrounded by numerous distinct rings or laminæ. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. The grains are very irregular in size, the smallest are just perceptible, and the largest are frequently $\frac{1}{300}$ of an inch in length, and large enough to be seen with the unaided eye. A very decided cross is seen when viewed with polarized light, the arms of the cross radiating from the nucleus of the grain and not from the center as it does in some other kinds of starches.

This is the cheapest and therefore the most common of all the substances used for adulterations both of wheat flour and of the spices. There are from $800,000 to $1,200,000 worth thrown upon the market annually from the New England States, and probably the most of it is used for adulteration.

Potato flour is considerably heavier than wheat, so in examining the different layers of the little cone composed of the sediment it would be found, if present, in a layer beneath

the wheat, that is, near the tip of the cone. It is more readily acted upon by a weak solution of potassic hydrate than wheat. The solution should be 1.75 parts of potassic hydrate with 100 parts of distilled water. This expands potato starch while it does not seem to affect wheat. The potato starch grains swell up to an enormous size, frequently fifteen times their original dimensions, while the rings are entirely destroyed which gives them a flake-white appearance. A weak solution of iodine will affect potato starch much quicker than it will wheat. Still both the potassic hydrate and the iodine will affect the wheat starch, although the statement has been made several times that such is not the case. The truth of this can easily be proved by trial. Nitric acid has the property of coloring flour an orange yellow while it does not change the color of potato starch. If the specimen of flour be adulterated with potato starch it will not assume the same bright yellow color which pure flour has on the application of nitric acid.

The presence of potato starch may generally be detected, even with the unaided eye, by the minute glistening appearance or the scintillations which are so characteristic of potato starch. The structure of the potato itself is very simple, the whole of the central part being made up of large hexagonal cells with very thin walls, and they are packed full of starch. A very good idea of their appearance is obtained from the illustration of the hexagonal cells of wheat, Fig. 5, page 118 of the April *American Miller*, 1880. So in addition to the starch grains when examined under the microscope, we occasionally see very delicate fragments of cellulose. Any person who intends making a study of this subject should become perfectly familiar with the appearance of potato starch under the microscope before he attempts to examine wheat flour for its adulterations.

Indian Corn, or maize, is one of the most common adulterations of wheat flour. The name corn is frequently applied to the fruit of all the cereals, and so it was used when mention was made of corn in the Bible and in Roman history, while Indian corn was known only after the discovery of America. The botanical name is *Zea Mais*, and belongs to the family of *Gramineæ*. It is a native of tropical America,

although it grows in the greatest abundance through the whole continent. It is found in its wild state in Paraguay and Chili. The cultivation of maize has within the last century increased to an enormous extent over the American Continent and throughout the most part of Asia, Africa, and Southern Europe. In the United States in 1870 there were raised 760,944,549 bushels of corn. It requires so little labor for its production, that it is among the most popular and cheapest grains cultivated, and consequently is produced by the poorer people of almost every country.

It is a most beautiful plant, and were it not so common it would be cultivated as an ornamental plant for the lawn and the flower garden. There are many different varieties of the foilage, some with broad leaves thrown off from a tall and stately plant, while others are dwarfs, growing only a foot, or a foot and a half high with beautifully striped leaves.

Some writers have claimed great antiquity, and an Eastern origin for maize; while others and able botanists have disagreed with them strongly. M. De Condolle says, "Maize is of American origin, and was not introduced into the old world until after the discovery of the new. It was found to be cultivated by the aborigines from New England to Chili." The poet Barlow has said the same, though in a different way:

> Assist me first with pious toil to trace
> Through wrecks of time thy lineage and thy race;
> Declare what lovely squaw, in days of yore
> (Ere great Columbus sought thy native shore,)
> First gave thee to the world; the works of fame
> Have lived indeed, but lived without a name.

Varieties not now in cultivation have been found in tombs of an antiquity greater than that of the Incas; and Darwin discovered "heads of maize embedded in a beach which had been upraised at least 85 feet above the level of the sea."

Recent analyses shows the following percentage of nutritive principles, as made by Dr. Dana:

Starch, oil, sugar and zeine	77.09
Nitrogenous matter, albumen	12.60
Water	9.00
Salt	1.31
	100.00

The ash contains a large proportion of phosphoric acid in combination with lime and other bases. The amount of fatty matter or oil is notable, varying with the kind of corn from six to eleven per cent. The hard flinty kinds of corn have the most, and the starchy kinds the least, oil.

Wheat contains about one and a half per cent. of fatty matter. The only objection to corn seems to be a deficiency of glutin or of nitrogenous substances as compared with wheat, for there seems to be no glutinous residue left when washed with water as there is in wheat. It is said by Gorham, to contain a red-

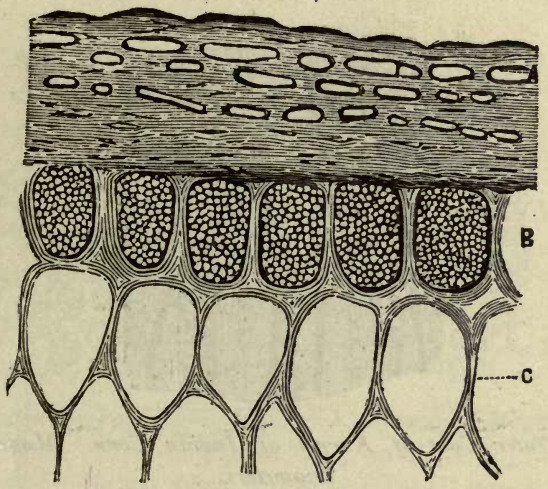


Fig. 3. Cross Section of a Kernel of Indian Corn. Magnified 350 Diameters. Drawn with the Camera Lucida.

dish nitrogenous substance, to which he has given the name *Zeine*.

The testa of the kernel of Indian corn, or the fruit and seed-coats are reduced to two only. The epidermis, or outer coat, consists of one row of longitudinally elongated, tabular cells, where the thick, coarsely dotted wall is noted for the bearded appearance of its margin. See Fig. 4. The inner coat is composed of six or seven layers of parenchymatous cells, all running in one direction, and about three times as

long as broad, having very strong walls. They are seen only in shadowy outline in Fig. 4. The outer layer of the albumen consists simply of one row of cells; thick-walled, nearly square and loaded with albuminoids. In Fig. 5 we see these cells as they have been cut off from the kernel parallel with the outside. While in Fig. 3, *b* we see them on a cross section. These cells are very similar to the albuminous cells of all the cereals as well as many other seeds. The central part of the kernel is composed of large thin-walled cells loaded with starch. See *c*, Fig. 3. A large white embryo occupies the whole of the lower part of the kernel.

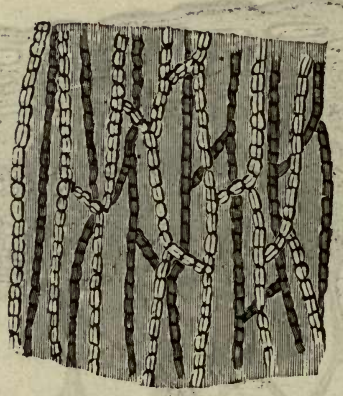


Fig. 4. Outer Coat of Kernel of Indian Corn. Magnified 200 Diameters.

The starch grains of corn (see Fig. 6), are generally bounded by plane faces and angles instead of curved faces, as in wheat and potato. There are no rings and no indications of any present. There is quite a depression at the center of each of the faces. This depression is quite common in the starches of oat, rice and buckwheat, as well as corn. In the process of drying, the center of the grain or the nucleus shrivels up in a peculiar and characteristic manner, which gives the appearance of stars or crosses on each of the faces, though it is sometimes only a little black spot. In fresh grains of corn starch this central depression together with the disc-shape

of some of the grains gives them a general resemblance to the blood discs of the mammalia, according to Hassell. The depressions are due to the evaporation of more moisture from the center of the grain than from any other portion. The starch grains developed in the outer part of the kernel of corn are much more angular than are those of the central part. The angular appearance of these grains is due to the way in which they are packed in the cells, each accommodating himself to his neighbor. So they look when taken out as soft pills would look were a number packed together in a small place. They are without a definite shape, and yet all having the same gen-

Fig. 5. Outer layer of Cells filled with Albumen. Magnified 200 Diameters.

eral appearance. They are never found forming definite compound bodies as in the oat and buckwheat, as we will see later.

The starch grains of Indian corn average about $\frac{1}{1600}$ of an inch in diameter, and there is quite a uniformity of size among the different grains as compared with the starch grains of potato.

When these starch grains are examined under polarized light well defined crosses are seen, the arms of the cross radiating from the nucleus at the center of the grain instead of from one side, as in the potato starch. When subjected to dry heat the shape of the grain is but little changed, while if

subjected to moist heat the shape is entirely destroyed. A solution of iodine turns the starch grains to a lighter blue, and potassic hydrate expands them like boiling water. The starch separated from all other constituents of the grain forms an important article of diet, which is sold under the name of "corn flour." While "corn starch" is proverbial for its laundrying properties.

It is estimated that maize is eaten by a greater number of human beings than any other grain, excepting rice. Its analysis shows it to be admirably adapted to sustain life, and to furnish material for the growth of both human beings and

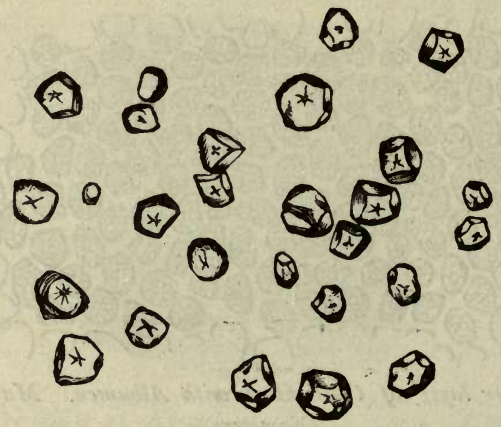


Fig. 6. Grains of Corn Starch. Drawn with Camera Lucida. Magnified 475 Diameters.

domestic animals. For maize is a highly concentrated nutriment, and is capable of serving, as it does in some tropical countries, as almost the sole food of the population. It is a most common article of diet with all Americans, and, on account of its cheapness, is within the reach of the poorest. It has been estimated that, if cooked in the right way, a meal can be made from corn costing only one-half a cent a person. In the Southern States it constitutes a primary article of food, for rich as well as poor, old as well as young. In all of its various combinations, it belongs to the table as do the

dishes themselves. It enters into the dietary of many of our public institutions and charities. Although it is used to such an extent among the farming population, it is little used in the cities, except as a relish. As "green corn," the supply furnished to the cities is perfectly enormous. Perhaps there is no article of food which is capable of being served in such a great variety of ways as corn. Hominy, hulled corn, pop-corn, and corn meal; while hasty pudding is far from being the least, and whose praises were sung in verse :*

"Some tawny Ceres, goddess of her days,
First learn'd, with stones, to crack the well-dry'd maize;
Through the rough sieve to shake the golden show'r,
In boiling water stir the yellow flour—
The yellow flour, bestrew'd and stirr'd with haste,
Swells in the flood, and thickens to a paste,
Then puffs and wallops, rises to the brim,
Drinks the dry knobs that on the surface swim;
The knobs at last the busy ladle breaks,
And the whole mass its true consistence takes.
Thy name is *Hasty Pudding!* thus our sires
Were wont to greet thee fuming from their fires;
And while they argued in thy just defense,
With logic clear they thus explain'd the sense :—
In *haste* the boiling cauldron o'er the blaze,
Receives and cooks the ready-powdered maize;
In *haste* 'tis served, and then in equal *haste*,
With cooling milk, we make the sweet repast,
No carving to be done, no knife to grate
The tender ear, and wound the stony plate,
But the smooth spoon, just fitted to the lip,
And taught with art the yielding mass to dip,
By frequent journeys to the bowl well stor'd,
Performs the *hasty* honors of the board."

Corn is used as fuel in many localities, upon prairie farms, where wood and coal are expensive; while corn cobs are a favorite for kindling wood on almost every farm. It is said smokers like a pipe where the bowl is made from a corn cob. Then the stalks and the leaves are of great value as cattle fodder, while corn is often sown for the sake of fodder only. The leaves of this plant have been manufactured into paper. An

*Written by Joel Barlow, Minister Plenipotentiary to France, in 1793.

Austrian, Von Welsbach, invented a process by which the fibers of the stalk, leaves and husks could be converted into paper. The juice of the stalk, before the grain ripens, has been converted into sugar and syrup, although it cannot compete with sorghum; so, indirectly, alcohol and whisky are produced from the plant. The oil is in such large quantities that it has been utilized for illuminating purposes. It is so very expensive ex-

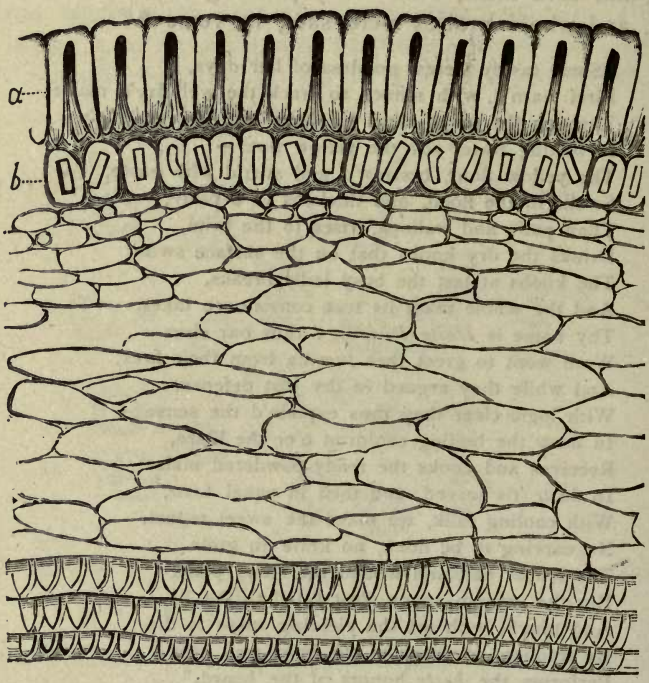


Fig. 7. Cross Section of the Coats of Bean. Drawn with the Camera Lucida. Magnified 400 Diameters.

tracting the oil, that it probably never will have general use as an illuminator. The leaves are used for upholstering purposes, husk mattresses being quite common. The more delicate leaves of corn are plaited into fancy articles, and we have from these braids, matting, slippers, hats, horse-collars, etc.

Indian corn is met with, in the state of a coarse flour, in

the shops, under the name of "Polenta." It is frequently mixed with a poor quality of wheat, and sold under the name of "Wheat," or "Amylum." Even if it were as palatable, and more nutritious than wheat flour, yet a substitution always deserves the greatest condemnation.

Corn flour appears also in market under the name of maizena, maizone, etc. Recently the writer was called on to examine some so-called "Baby Food" that sold for seventy-five cents a pound. It was imported from France, and claimed to be made from the finest wheat flour. On examination it was found to be only corn starch.

Notwithstanding the fact that corn is so common, and so

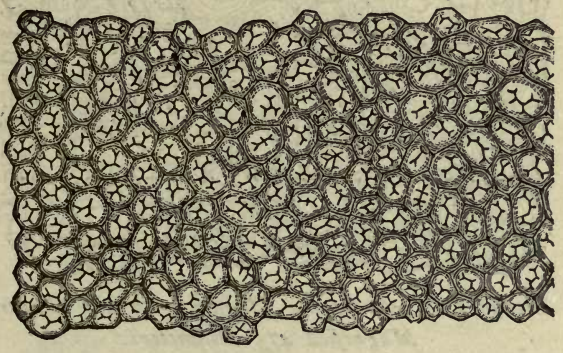


Fig. 8. Outer Coat of Bean. Drawn with Camera Lucida. Magnified 475 Diameters.

cheap, even this is subjected to adulteration. The most common substances used are beans, peas, oats, buckwheat, potatoes, and the other ingredients which have already been mentioned as forming a part of wheat flour.

Bean.—Among the most common adulterations of wheat flour is found bean. It seems to be a favorite ingredient for mixing with a poor quality of flour, and the very small class of millers who are in the habit of selling compounds to the public under the name of wheat flour, use bean flour quite extensively. It is cheap, wholesome, easily obtained, and makes a tenacious dough. The botanical name of our common bean is

Faba vulgaris. It belongs to the natural order *Leguminosæ*, and the sub-order *Papilionaceæ.* It has been cultivated in Asia and Europe since the earliest ages. It originated in the East, and is said to be still found wild in Persia. Although it dates from so ancient a time it is yet cultivated extensively over the whole world, and is used for food in all countries for men, cattle and swine. There are many different varieties cultivated and sold in market under various names, as Lima, Kidney, Winsor, black-eyed beans, etc. The Lima bean is extensively cultivated in America, and furnishes an important article of diet.

Fig. 9. Second Coat of Bean. Drawn with the Camera Lucida. Magnified 475 Diameters.

The common bean is either a running vine, trained on frames, bushes or poles, or a bushy shrub growing one or two feet high. It has pinnate leaves, without tendrils, and fragrant flowers. The seeds, which are the nutritious food, are inclosed in long pods, that are woolly on the inner surface. These pods, when green, and yet containing the soft green beans, are used for food. When fully ripe, the seeds are softened by soaking in water and then boiled or baked—baked beans having almost a world-wide reputation—or they are ground into a meal, thus making bean flour. The plant grows rapidly and luxuriantly, and it does not exhaust the soil, yet it requires a rich soil for its habitation. Beans are not cultivated to-day as extensively as they were before the introduction of

turnips and clover. It is supposed by many that the common bean is much more nutritious than wheat. It contains a high proportion of nitrogenous matter, under the form of legumin. It is, on this account, rather a coarse food, and difficult of digestion, although it is regarded as the best of food for horses, by many as far better than oats.

The Greeks and Romans regarded beans with very great interest. They were used by them as ballots at the time of the election of magistrates. Among them a white bean signified the affirmative, and a black one the negative. Ovid gives a description of an important custom which existed among the ancients. He says: "Beans had a mystic use, for the master

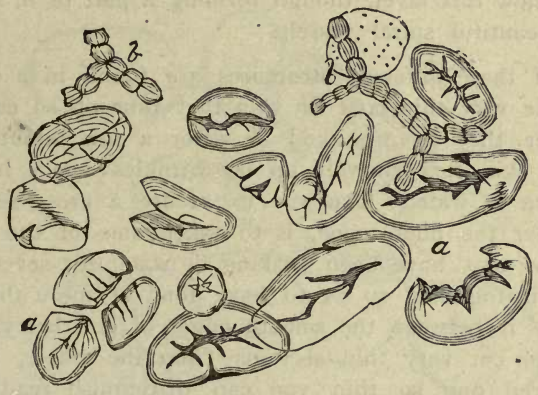


Fig. 10. Bean Starch after being Baked as in Bread.

a, Starch grains. *b*, Fragments of cell-walls.

of the family, after washing his hands three times, threw black beans over his head nine times, continuing to repeat the words, "I redeem myself and my family by these beans." Pythagoras urged abstinence from the use or contact of beans, and the Egyptian priests considered the sight even of beans to be unclean. Cicero used to maintain that beans were a great enemy to tranquility of mind.

There are three distinct coats surrounding the bean. The outer seed coat, as seen at *a* figure 7, the middle seed coat seen at *b*, and the inner coat, consisting of all the remaining structure. The first, or outer coat *a*, is made up of radially

elongated cells, having somewhat the appearance of teeth. These central openings that approach so near the top of the cell, are not of a uniform width, but are irregular, so if the section had been cut a trifle nearer either end of the bean, we should see some of the openings larger and some smaller than those seen in the illustration. The walls are thick, indicating a strong structure. The second or middle coat *b* is composed of thin-walled, nearly square cells, each cell containing a crystal. The crystals are of uniform shape and appearance, and stand up like sentinels in each cell. The third, or inner seed coat, consists of loosely packed, irregular, thin-walled cells. They are empty and collapsed, though they swell out when soaked in water. Below this layer, though forming a part of it, are found rows of beautiful spiral vessels.

All of these different structures are found in a cross section of the very thin coat or skin that rubs off so easily from beans after they have soaked in water a few minutes. It is this same skin that shrivels up or wrinkles when beans are first thrown in water. The way to secure a cross section for study under the microscope, is to take some of the thin skin from beans that have been soaking in water for several hours, and fold it together, so as to have four or more thicknesses, then place it between the smooth edges of elderberry pith and continue to cut very thin sections from the whole, until you have secured one so thin you can distinguish readily all of the different structures. A sharp razor or section cutter will be needed for making the section.

If from the outside of a bean which has been soaking in water for several hours, the outermost part of the skin be picked or cut off with a razor, we can see the surface of the outer coat, as in figure 8. The cells are now seen on the upper surface, and they are quite regular in size, surrounded with plane faces or angles, rather than being round, although they do not all have the same number of sides. Each cell is furnished with a central depression, and the center or lowest part of the depression seems to be a line broken abruptly, and the ends branching regularly, two at a time. This coat always presents a beautiful appearance under the microscope. It is

almost impossible to separate the outer and middle coats,—that is, *a* and *b* of figure 7. If the little specimen we have on the glass slide be turned over we shall see the surface of the middle coat, as seen in figure 9. This coat is composed of a single row of thin-walled cells, each containing its sentinel crystal.

The starch grains of bean are of particular interest, for they contain characteristics peculiar to themselves. The starch grains are oval or round, very similar in shape to the beans themselves. Then there is a central line or mark through the grain, corresponding to the mark on the back of the bean where it is

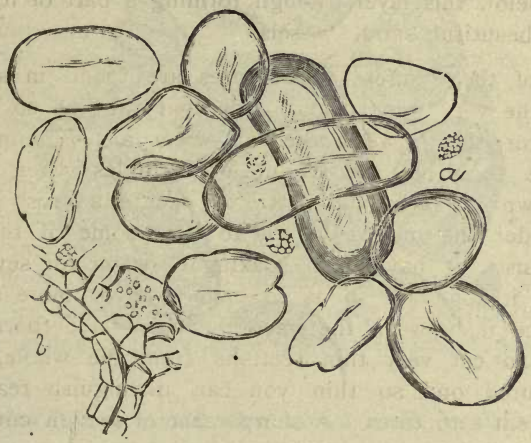


Fig. 11. Bean Starch after being Boiled, as in Pudding.

attached to the pod. This line is ragged and uneven in shape, though it marks the nucleus. So great is the resemblance to beans that persons in looking at the starch seem to think they are looking through a glass dimly at the beans themselves. Near the edge of the starch grain, but seldom extending to the center, are seen dark rings, quite fine and numerous. The grains average $\frac{1}{600}$ of an inch in length, and $\frac{1}{1000}$ of an inch in width.

When the starch grains of bean are subjected to a high degree of heat, but with no moisture present, the grains be-

come brittle, and the nucleus is destroyed ; the rings are not affected, but the edge becomes broken and ragged. Bean flour will seldom be subjected to an intense dry heat. In all kinds of baking, and in the treatment of the flour wherever heat is used, there is more or less moisture accompanying it. Where there is an extreme moist heat there is a great change produced in the starch, but not enough to destroy its identity. A microscopist can detect the presence of bean starch when mixed with wheat, even after it has been baked into bread. Figure 10 gives us the appearance of bean starch after it has

Fig. 12. Cells of Bean loaded with Starch and Glutin. Magnified 475 Diameters. Drawn with the Camera Lucida.

been baked. The moisture of the dough has caused the grains to expand slightly, while the heat has rendered them brittle and ragged. The nucleus and rings are slightly affected. At *b* some of the cellular structure appears.

In figure 11 we have some of the starch grains after they have been boiled in a pudding. They show very little resemblance to the original grain, yet it is sufficient when you see a large quantity of the grains to identify them. They have swollen to an enormous size, have lost their rings, though they retain their nucleus as well as their general shape. At *b* can

be seen how great a change is produced in the wall of cellulose by boiling. It would be impossible with any one starch grain, or with even a small number, to tell definitely just what treatment the starch grain has undergone. It is only when you examine a large quantity, and even then you can not tell the extent of the baking or the boiling by its appearance under the microscope. The entire bean, after the thin skin is removed, consists of large cells loaded with starch and glutin. (See figure 12.) The cells are generally hexagonal, thick-walled, and quite large. There are only a few starch grains contained in each cell, as compared with the way the starch grains of wheat are packed in their cells. Lying close to the walls and filling up all the space between the starch grains, are the fine granules of glutin.

A microscopical examination of bean flour reveals all of the structures represented in the illustrations, and they are so different from the structures found in wheat, as to be easily identified. Nitric acid forms an important test for the presence of bean flour. Whenever wheat flour with which powdered beans are mixed, is brought in contact with nitric acid and ammonia, it immediately assumes a deep red color. The presence of bean flour, when mixed with wheat flour, may be detected generally by the peculiarly strong odor of beans, and by the darker or yellowish gray color which the wheat flour assumes.

Barley, Rye, Oat and Buckwheat.

Barley is found principally in the temperate region. There are four distinct species and from these many old varieties have been cultivated and new varieties are yet being developed. Barley is the most hardy of all the cereals, its limit of cultivation extending farther north than any other, and at the same time it can profitably be cultivated in some of the tropical countries. Pliny claimed that barley was the most ancient food of mankind. No less than three varieties have been found in the lake dwellings of Switzerland, in deposits belonging to the stone period. According to Professor Heer two of the kinds found there are the most common varieties of to-day. The smallest, the most common, and the most ancient known, is the *hordeum hextastichum sanctum.* The Goddess Ceres generally has ears of this variety decorating her hair, while it is also found stamped upon ancient coins.

Barley has formed an important article of food in some of the northern countries, but on account of its deficiency in gluten as compared with wheat, it can never be a popular flour for making bread. It has some redeeming qualities, however, for we are told the Greek athletes were trained on this diet. As to importance both in an agricultural and commercial point of view barley is the grain crop ranking next to wheat. It is cultivated principally for malting purposes, and of all the cereals is the best adapted for this, containing as it does more starch and less gluten, and about 7 per cent. of ready formed grape sugar. Good barley should have a thin, clean, wrinkled husk closely adhering to a full, plump kernel, which when broken appears white and sweet, with a germ full and of a pale yellow color.

The fruit coats of a grain of barley differ considerably from those of wheat. There are four layers of longitudinally arranged

cells. The walls of the outer layer are wavy, but not beaded as in wheat. There are three layers of transverse cells and the walls are not wavy. There are also generally three layers of cells containing the gluten or nitrogenous substances. All of these cells are more delicate than the corresponding ones of wheat. The cells of the central part containing starch are also more delicate, and when empty resemble thin walled fibrous structure.

If we cut open a kernel of barley and scrape a little of the white powder from the center, we will find there are present two kinds of starch grains, both large and small. The large grains are lenticular; when seen on the face they are round or nearly so, but when seen on the edge they are oval, frequently showing a longitudinal furrow. A faint nucleus is present

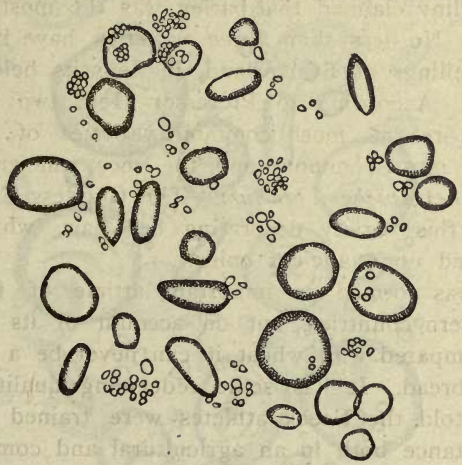


Fig. 1. Barley Starch. X 475. (*Drawn with the camera lucida.*)

and faint rings are seen in a few of the grains, though not in all of them. The average size is about one sixteen-hundredth of an inch in diameter. The small grains are angular, dark and not collected in masses as in many of the starches. The whole appearance of barley starch is much more delicate than that of wheat. The large grains are smaller, more nearly spherical and more opaque. The small grains are smaller, more uniform in size and fewer in number than the corresponding ones

of wheat. These small grains are one seven-thousandth of an inch in diameter, and frequently have a nucleus. There is no cross when viewed with polarized light.

Rye is probably a native of Southeastern Europe and Southwestern Asia. It has been cultivated for ages and is still grown in the most of temperate climes. Rye is frequently used as an adulteration of many of the commercial spices. Roasted rye is frequently found mixed with coffee, and has been reported as one of the ingredients found in wheat flour. Rye is obtained from *Secale cereale* and the kernels resemble wheat only smaller. The cells of the fruit coats are smaller, more delicate and more finely beaded than wheat.

There are two kinds of starch grains, large and small, found in rye. The large grains are quite irregular in their size, some

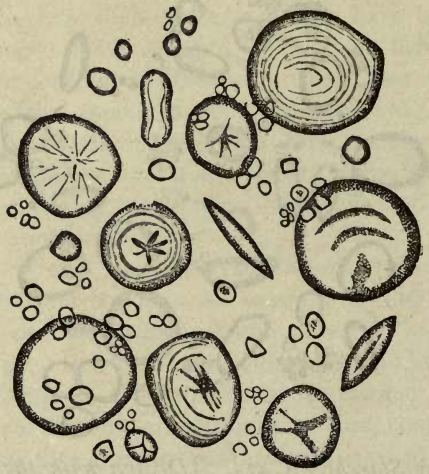


Fig. 2. Rye Starch. X 475. (*Drawn with the camera lucida.*)

being as small as barley, while many are several times larger than the largest grains of wheat. They are lenticular with a great difference between the two diameters, so when the grains are seen on the edge they are quite slender. The very large grains are flake-like, more transparent, devoid of rings, and frequently have several lines radiating from the central nucleus. Rings are seen in the smaller ones of the large grains, which

are more opaque and thicker than the others. The small grains are quite numerous and very small; they are smaller than the corresponding grains of wheat, while the large grains are very much larger. A strongly marked cross is seen with the polarized light in the large grains of rye starch.

Oat was formerly much used as food for man, especially in cool climates, where it is cultivated with the best success. Its native country is not certainly known, though probably Northern Europe or Asia. There are several distinct species of oats, the one generally cultivated in this country is *avena sativa.* Oat

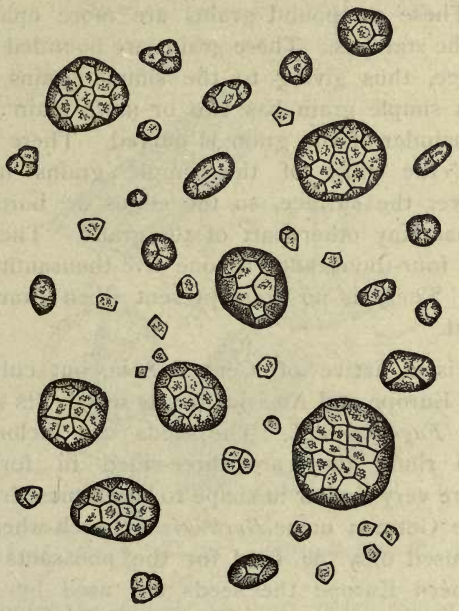


Fig. 3. Oat Starch. X 475. (Drawn with the camera lucida.)

flour does not form a dough or paste like wheat flour, so it can never be used as a substitute, although it is frequently mixed with wheat and sold under the name of wheat flour. Oat flour, however, contains a large amount of nitrogenous matter. The grains or kernels of oat are usually found in market inclosed in their husks. The first fruit coat of oat is com-

posed of several layers of cells. The cells of the first layer are large, long and bordered with thin beaded walls. From the cells of this outer layer of the first fruit coat, and from any point on its surface, arise long epidermal hairs, always turning toward the apex of the grain, where they are much more numerous.

Oat starch is composed of both compound and simple grains. The compound grains are oval, egg-shaped or spherical, and are composed of from three to twenty grains. The dividing lines between the single grains show quite distinctly. They are from one two-thousandth to one eight-hundredth of an inch in diameter. These compound grains are more opaque than the majority of the starches. These grains are bounded by a smooth, curved surface, thus giving to the simple grains their peculiar shape. Each simple grain has two or more plain faces or sides, while the remainder of the grain is curved. There is no nucleus present, but the most of the simple grains have a slight depression over the surface, so the edges or borders are more prominent than any other part of the grain. The small grains are from one four-thousandth to one five-thousandth of an inch in diameter. There is no cross present when examined with the polarized light.

Buckwheat is a native of Central Asia, but cultivated extensively in Europe and America for its seed. Its scientific name is *Polygonum Fagopyrum L.* The seeds are inclosed in a dark brown tough rind; they are three-sided in form with sharp angles, and are very similar in shape to beech-mast from which fact it derives the German name *Buchweizen* (beech-wheat). In Great Britain it is used only as food for the pheasants and poultry, but in Northern Europe the seeds are used by all classes of people for food. In the Russian army, buckwheat is served out as a part of the soldiers' rations. It is used to some extent throughout the United States for food. Buckwheat is poor in nitrogenous substances and fats as compared with the other cereals. It is a favorite crop for very poor land, as it grows with great ease and rapidity. Buckwheat flour is frequently found mixed with the poor qualities of wheat flour. Its color and properties prevent it ever being substituted for wheat flour.

Buckwheat starch (Fig. 4) is composed of both compound

and simple grains. The compound grains or masses are either cylindrical or prismatic. When cylindrical the curving surface is perfectly smooth, but the ends are irregular as though they had been broken. These masses are very numerous and characteristic, unfortunately they closely resemble the cell contents of black pepper. These compound grains are much larger than those of oat. They are quite opaque and show distinctly the divisions into small, single grains; many of the small grains are like the corresponding ones of oat in having two or more plain sides and the remainder of the grain curved. They are larger than oat, being one three-thousandth to one sixteen-hundredth of an inch in diameter They are quite irregular in size, and generally a nucleus is present. There are no rings.

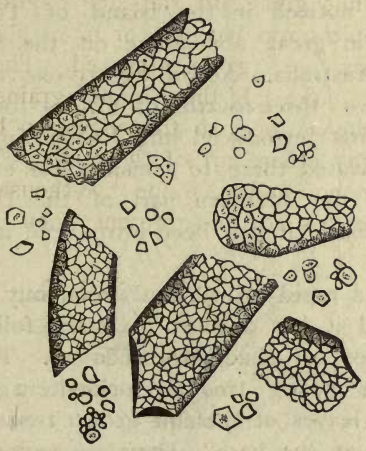


Fig. 4. Buckwheat Starch. X 475. (Drawn with the camera lucida.)

If you suspect the sample of flour which you are examining contains either oat or buckwheat, it will be much easier to examine it first with a low magnifying power (something less than 150 diameters) and decide the question of the compound grains or masses first, then examine it with a higher power. Fortunately for humanity the best qualities of flour are almost invariably what they profess to be, "pure wheat flour." The mixtures and adulterations of other flours and too often mineral substances are found in the cheapest, poorest flour in market.

EUCALYPTUS GLOBULUS.

CONSIDERABLE interest has been excited lately on the subject of a new remedy which bids fair to rival for malarial troubles the old stand-by, quinine. This specific is known scientifically as *Eucalyptus globulus*, and commonly as blue gum-tree. It belongs to the natural order Myrtaceæ.

It was first noticed in the island of Tasmania in 1792, while it grows in great abundance on the moist slopes and woody hills of Australia. According to one author, a Frenchman, it constitutes three-fourths of all the forests of that continent. It was first introduced into Europe in 1856, since then it has been cultivated there to considerable extent, and also in northern Africa, the southern part of the United States and California. Recently it has been introduced into Italy in large quantities.

The tree is a rapid grower and frequently attains the height of 300 feet, and it has a most luxuriant foliage which makes it a beautiful tree for shade or ornament. The leaves of the plant or of the young tree are opposite and cordate at the base; while the leaves of the full grown tree are alternate and slightly rounded at the base. They are very long and slender, generally curved or crescent shaped and tapering at the apex to a long acute point. They are from 8 to 15 inches in length and in their broadest part only from ½ to 1½ inches in width. There is a prominent, coarse mid-rib present, with secondary ribs running the entire length of the leaf parallel with and very near the margin, while the margin is entire and smooth, being protected by a thickened wall of cellulose. Both the upper and under surfaces are dotted with prominent glands filled with resin or with oil. The leaves are of a yellowish green color, while the midribs, veins and margin are white. They are of a leathery consistency, with a peculiar, strong odor of pine and an

Fig. 1—Eucalyptus Leaf.

aromatic, pungent taste, slightly bitter, followed by a sensation of coldness.

The microscopical structure of the leaves is quite characteristic. A cross section, when magnified only a few times, shows the large resin-cells loaded with bright brick-red resin and the smaller oil glands in which float the oil drops of a bright yellow color. When magnified more highly the minute structure of the leaf is seen plainly. In figure 2, we have a cross section of the leaf cut directly through the midrib. The midrib is composed mostly of wood and liber fibre which gives such great strength to the frame work of the leaf. On the upper and under surface, and in fact entirely covering it, is a very thick wall of cellulose which is nearly impervious to water and to the sun's rays; at A we see this thick wall that stands duty over

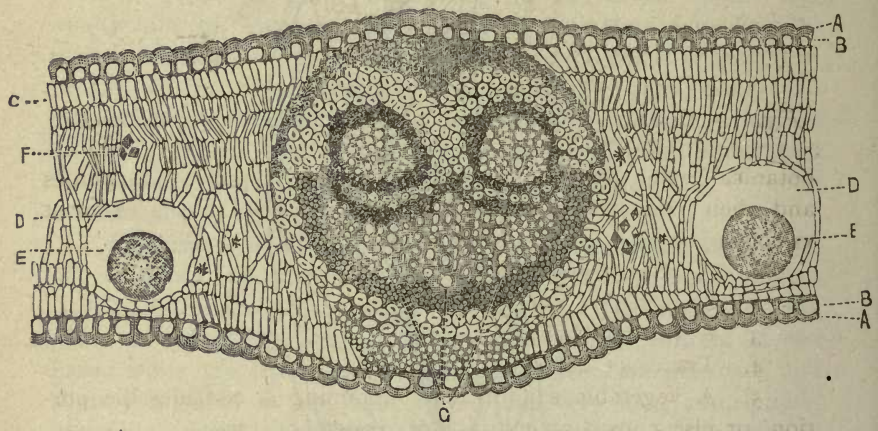


Fig. 2.—Cross Section of an Eucalyptus Leaf. x50 diameters.

the delicate central portion. The epidermis seen at B is a single row of empty cells whose only object in life apparently, is to give a chance for the circulation of air between the outer garment of cellulose and the body of the leaf. The green portion of the leaf is composed entirely of the delicate elongated cells loaded with coloring matter called chlorophyll, while to the row of cells seen at C has been given the imposing name of palisade cells. Palisade cells are common to all leaves.

Some of the large oil glands so numerous in the leaf, are seen at D containing yet a drop of oil, E. The whole leaf is loaded with the most beautiful crystals; see F. Some of these crystals separated from the leaf and greatly magnified are seen in figure 3. The prismatic crystals are calcium oxalates. The

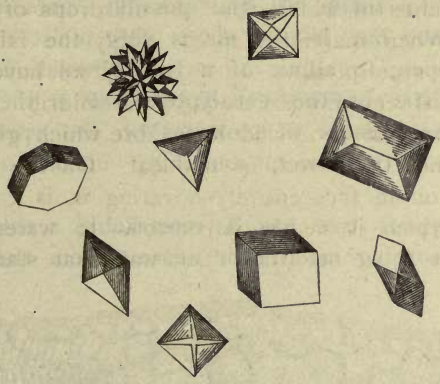


Fig. 3.—Crystals from the Leaf of Eucalyptus. x750 diameters.

botanical name for the rosettes of pointed crystals is raphides and their composition according to Dr. Lionel Beale is most various :

1. A little organic matter.
2. Sulphate of lime.
3. A little carbonate of lime.
4. Traces of chloride of sodium.
5. A vegetable salt of lime containing a considerable portion, or else consisting entirely of oxalate of lime.

The virtue of eucalyptus depends upon a volatile oil; of this oil the fresh leaves yield 2.75 per cent., and the recently dried leaves yield 6 per cent. This oil is composed of two camphors, the larger proportion of which is known as eucalyptol.

The leaf is supplied with quite large stomates or breathing spores or mouths; see figure 4. These stomates connect directly or by means of little openings between some of the palisade cells with the center of the leaf, so that air and moisture are carried all through the leaf between the loosely packed structure, until it reaches the end of a spiral vessel.

The spiral vessels are the connecting links between the air of the outside world and the roots of the tree. In making the cross section of the leaf some of the spiral vessels were cut across and can be seen at C figure 2. When the atmosphere around the tree is very dry you will find these stomates closed tightly so as to retain all the possible amount of moisture within the plant; but if the air is very moist these stomates will be wide open, to admit of a free circulation. A remarkable characteristic of the eucalyptus leaf is the presence of nearly the same number of stomates on the upper surface of the leaf, as upon the lower, something uncommon except in water plants.

The eucalyptus tree has a remarkable reputation just at present, for absorbing malaria or miasma from the surrounding

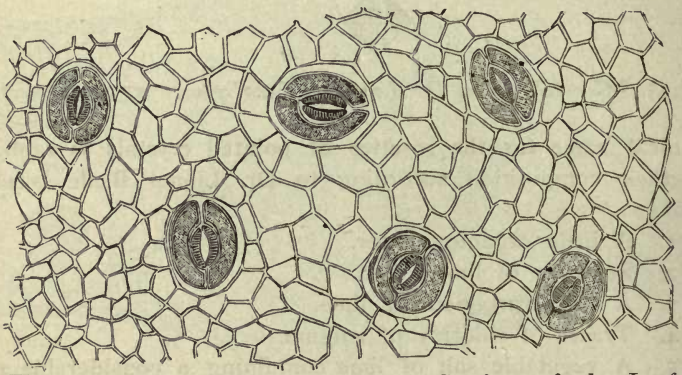


Fig. 4. Stomates from the Upper Surface of the Leaf. x250. Drawn with the Camera Lucida.

atmosphere. So large tracts of land in the Campagna di Roma have been devoted to raising a forest of eucalyptus trees. Some advanced botanist has suggested this virtue of the tree was due to the great number of stomates on the leaves, and it seems a safe theory to adopt.

Through southern California the eucalyptus trees are being systematically cultivated for fuel. Two hundred and twenty-five trees are generally planted to the acre and it is estimated that

two acres of the growth will supply the family constantly for fuel. Fresh growths start much more rapidly from the old trunks, that were left after cutting the trees down, than from fresh plants. Ten acres of this tree were planted in Alameda county, California, which at the end of seven years netted $1,190, and there were left 1,000 of the largest trees that will in a few years develop into some of the best kinds of wood for manufacturing purposes.

Some very fine specimens of Eucalyptus leaves were furnished me for this article by Parke, Davis & Co.

Jaborandi. Pilocarpus Pennatifolius.

Pilocarpus pennatifolius was first found in the southern provinces of Brazil. It was introduced from there into Europe in 1874, where it is now cultivated in the various botanical gardens on the continent and in England.

It belongs to the order Rutaceæ, and to the tribe Xanthoxylaceæ, to the genus Pilocarpus and species Pennatifolius, while the common name is Pernambuco Jaborandi.

There has been in the past considerable confusion regarding the botanical position of Jaborandi. Dr. Peckolt has described seven different kinds of plants sold at the stores of Brazil under the common name Jaborandi. Four of these belonging to the Piperaceæ order, two to the Rutaceæ, and one to the Xanthoxylaceæ. Martinus has described still more. The Jaborandi, under consideration in this article, was introduced to the notice of the medical profession in Europe by Dr. Coutinho, of Pernambuco, in the spring of 1874. Since then it has been tried by many leading physicians in both Europe and America. It was in 1875 that Prof. Baillou, of Paris, referred it, from the examination of the leaf alone, to the genus Pilocarpus, and still later that Mr. Holmes, by an examination of the fruit, named it P. pennatifolius. The leaves and young shoots are the parts used as officinal, though it is not recognized in either the British Pharmacopœia or in the Pharmacopœia of the United States or of India.

DESCRIPTION.

Jaborandi is a small shrub, four or five feet high, only slightly branched, and the branches standing erect. The bark is smooth and gray in color, with numerous white dots covering its surface. The leaves (see fig. 1) are very large and compound. They are alternate, without stipules, and with long stalks, from a foot to a foot and a half in length. The leaflets are generally opposite, in

two to five pairs, and with a terminal one. The leaflets are three-and-a-half to four inches long, are oblong-oval, with pointed bases. They are very obtuse, rounded or notched at the apex. The margins are entire, rolling slightly backwards. The dried leaves are leathery in texture, smooth, free from epidermal hairs and glands, and of a bright brown on the upper surface. The fresh leaves are of a bright shining green on the upper surface, but much

Fig. 1. Pilocarpus Pennatifolius. a. Upper surface of the leaf. b. Lower surface. c. A part of the flower stalk with the flowers. Natural size.

paler on the lower surface, which is crowded with minute dots. These dots show as clear, nearly white spots, when the leaf is held between the person and the light. (See b, fig. 1.)

The long stalk bearing the flowers is from eighteen inches to two feet in length, being thickly covered with small flowers and buds. The illustration shows only a small piece of the flower stalk. (See c, fig. 1.)

MICROSCOPICAL STRUCTURE.

The cuticle is thick and granular, rather than smooth, apparently containing something besides cellulose. (See a, fig. 2.) Directly beneath this is a single layer of epidermal cells (b). The palisade cells (c) are longer and more slender than the average, and loaded with yellow chlorophyll and dead protoplasm. The cells of the loosely packed parenchyma are thinner walled and are more scattered than usual. They are nearly empty. Some of the smaller cells contain a pale, pink-colored oil, thin and clear ; while the oil drops, which are found floating around loosely, are of a

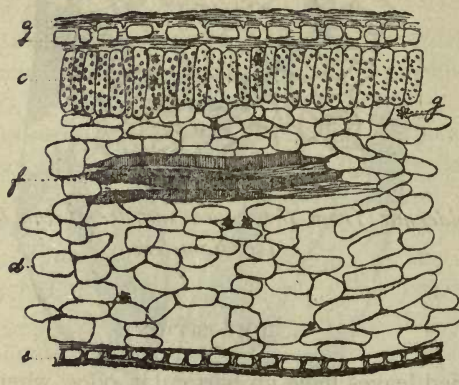


Fig. 2. Cross section of the leaf of Pilocarpus Pennatifolius. Magnified 250 diameters.

bright yellow, but rendered nearly opaque by the presence of a fine black granular substance. The lower epidermis (e) is smaller and more delicate than the upper. A small fragment of one of the veins or a vascular bundle, showing spiral vessels, is seen at f. There are numerous large stellate crystals found all through the structure of the leaf, rather than on either side of the vascular bundle, as is generally the case. Some are found even between the palisade cells and the upper epidermis. The crystals are of calcium oxalate. The minute dots seen on the under surface of the leaf are internal glands or large openings found on the inside of the leaf. They are always found among the loosely packed parenchyma, and connecting with the outside through a minute opening on the lower surface of the leaf. These contain a dark yellow

resin-like mass. But the mass does not entirely fill the gland. Occasionally small masses of resin are found scattered through the leaf.

Fig. 3 shows the epidermal cells from the lower surface of the leaf when magnified 250 diameters.

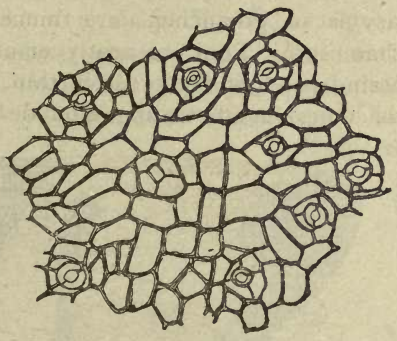


Fig. 3. Epidermis from the lower surface of the leaf. Magnified 250 diameters.

COMPOSITION.

The dried leaves have no particular odor when unbroken, but they have a perceptible aromatic odor when broken. Martindale says the odor "resembles a mixture of Indian hemp, matico and cubebs." The taste is feeble at first, but on chewing it is somewhat aromatic and bitter. At first it produces a warm, tingling sensation in the mouth, accompanied by an increased flow of saliva. The bark has a similar taste and odor as the leaves, but is more pungent. Rabuteau, who has experimented considerably with the leaf, believes the odor is due to a volatile principle, but not analogous to the essential oils contained in aromatic plants; and the bitter taste to a principle soluble in water and alcohol. Since then Gerrard and Hardy have proved the presence of an alkaloid, which they have proved possesses well-marked chemical and physiological properties. It is soluble in water, alcohol and chloroform. This alkaloid is regarded as the active principle of Jaborandi, and has been named Pilocarpine or Pilocarpia.

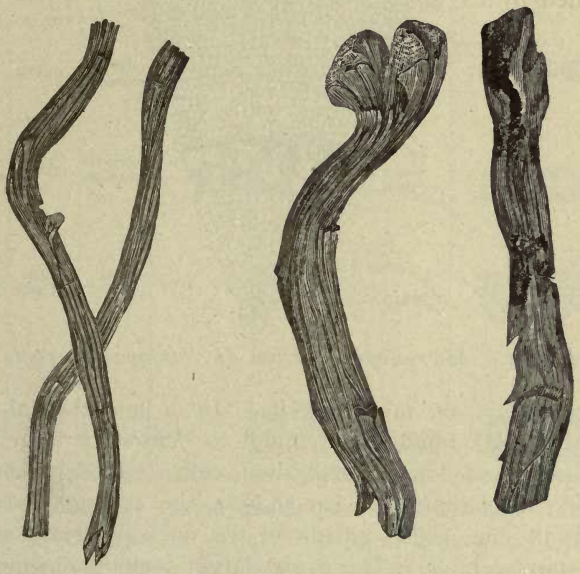
Besides pilocarpine, Jaborandi contains a volatile oil and various salts.

PROPERTIES AND USES.

Jaborandi has been proved by a number of observers to be a valuable diaphoretic. Pilocarpine has been found by some to be specifically antagonistic to atropia. Murrell concludes that the alkaloid is capable of producing, in a much smaller dose, the full effects of the drug itself. Harley states "that diseases associated with or dependent upon imperfect action of the salivary glands and the skin, are those which we may expect to be benefited by its use."

SARSAPARILLA.

SARSAPARILLA is of the genus *Smilax*, and is found a native of the northern part of South America and the whole of Central America. It is a woody climber and supports itself in



Honduras Sarsaparilla. Fig. 1. Jamaica Sarsaparilla.
(Natural Size.)

climbing by strong tendrils which spring from the stem of the leaf. The rhizome is short, thick, knotty, from which grows, in a horizontal direction, the fleshy roots. These appear in commerce several feet in length and from one-third to two-thirds of an inch in diameter, cylindrical and flexible, with a thick external cortical portion. On a cross section of the root (see fig. 2)

its woody portion which is composed of fibro-vascular bundles, is found near the central part, surrounded by a brown ring or nucleus sheath, see A figure 2. Within this nucleus sheath the bundles are so densely packed as to form a woody zone. The very centre of the section consists of white pith. Occasionally an isolated fibro-vascular bundle will be found. Outside the nucleus sheath we find the same structure as the pith, simple parenchyma. There is no bark proper, but in its place

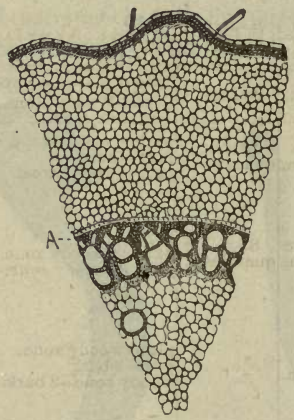


Fig. 2. Microscopic Section of Sarsaparilla root.

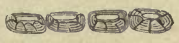
a thin epidermis of tabular cells. In a longitudinal section the fibro-vascular bundles are found to consist of large scalariform vessels and long thick-walled cells, called prosenchyma. In two of the varieties of sarsaparilla the parenchyma of the pith and all the cells outside of the nucleus sheath are loaded with starch grains. These are large compound grains $\frac{1}{2000}$ of an inch in diameter. Some of the cells contain needle-shaped crystals of calcium oxalate. In two varieties of sarsaparilla which do not contain starch, the prosenchyma and the vessels contain a bright yellow resin. The principal structure of interest in the whole texture of sarsaparilla is the brown nucleus sheath seen at A, fig. 2. This little narrow row of cells seems to be the guide by which the different varieties are determined, for each cell is characteristic of the variety to which it belongs. Each individual cell may be tabular and

tangentally extended, as seen in Honduras sarsaparilla, or they may be narrowly oval, as seen in the Mexican variety.

The secondary deposits may be uniform in width, as in Rio Negro sarsaparilla, or this deposit of cellulose may be found almost entirely on the inner surface, as in the Jamaica variety.

Below is given the differences, in a tabular form, of the four varieties of sarsaparilla which are recognized by the new National Dispensatory.

VARIETIES OF SARSAPARILLA.

Name.	Mealy or Not	Color.	Starch.	Width of Bark, Pith and Woody Zone.	Nucleus Sheath.
Honduras.	Mealy..	Pale brown.	Large quant'es	bark > woody zone. pith > bark. pith > woody zone.	
Rio Negro.	Mealy..	Orange brown.	Small quant'es	bark=pith. bark=4 woody zone. pith=4 woody zone.	
Mexican... *German P.*	Non-mealy.	Dull brown	None	pith=woody zone. pith=2 bark. woody zone=2 bark.	
Jamaica... *British P.*	Non-mealy.	Red ...	None	bark=pith. bark=1½ woody zone. pith=1½ woody zone.	

The Honduras sarsaparilla see figs. 1 and table, may be taken as the typical variety. It is of a gray or light brown color, striped or slightly wrinkled, about half an inch in diameter. When a cross section of the root is made it exhibits a thick parenchyma, or, as it is commonly called, bark, loaded with starch. While the Honduras is the variety generally used in this country, the Jamaica is the only one recognized by the British Pharmacopœia, and the Mexican is the only one the Germans recognize as officinal. There are nearly 600,000 lbs. annually used in the United States.

Fucus Vesiculosus.

ONE can hardly take up a pharmaceutical or medical journal of the day without seeing something in it about the wonderful anti-fat remedy—*Fucus Vesiculosus*. The questions naturally present themselves, where is it from? what is it? how does it look? With these questions in mind, we will study it for a short time.

It is found in great abundance on the shores of the Atlantic, from Greenland to the Canary Isles, both on the American and on the European coasts. It grows where it can a part of the time be covered by water and a part of the time be dry, so it is found between tide marks on almost all of the rocks and stones. It lines our Western coast from Kamchatka to California. It is used in large quantities in making kelp, and in many of the European islands and in Scotland is used as fodder for horses and cattle; while, on our Eastern shore, it is sold by the wagon-load as a fertilizer. No satisfactory chemical test has as yet been made. It contains much soda in saline combination,and iodine in the state of iodide of potassium.

We find mentioned in part "D" of the United States Dispensatory that *Fucus Vesiculosus* belongs to the cryptogamic algæ in the sexual system, and to the natural order *algaceæ*. There can be a question raised at this point, as there is no natural order known in botany as *algaceæ*. It does belong to the sea weeds—*algæ*—and is found in cryptogamic botany. For the use of those who would like to trace it out we give below a synopsis of the general plan.*

The *Fucus* is from two inches to two feet in length, and from one half an inch to an inch and a half in width. It grows attached to rocks or stones by an expanded disc-shaped root. The

*Botany: Phænogamic or flowering plants; Cryptogamic or flowerless plants: Ferns, Mosses, Lichens, Fungi (molds, rusts, blights etc.); Algæ (sea-weeds): Chorospermeæ (green algæ), Florideæ (red); Melanosporæ (brown): Phæsporeæ, Dictyoteæ, Sargassum, Fucus

Fucus has nearly a hundred varieties, the most prominent of which are vesiculosus, nodosus, serratus, fastigiatus, distichus, platycarpus, etc.

frond or leaf is flat ; the branches, irrespective of lateral displacements, all lie on one plane—though often twisted spirally—are thick, linear, and entire at the margin, branches by twos, is furnished with quite a prominent mid-rib. The air vessels, or blad-

Fig. 1. Fucus Vesiculosus. Natural Size. a. Air Bladder. b. Fertile end of the Frond.

ders, are globose or elliptical, formed by inflation of the substance of the stem or branch ; are mostly found in pairs, though sometimes absent. The substance is coarse and thick. The ends of

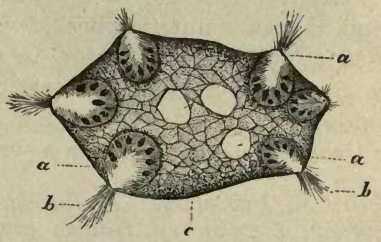


Fig. 2. Cross Section of one of the tips of Fucus Vesiculosus. (x 8 diameters.)

the branches are enlarged, forming bladder-like receptacles, having their surface covered with protuberances, ellipsoid, oval or spindle-

shaped, mostly in twos, as seen at *b*, fig. 1. It has a peculiar odor and a nauseous, saline taste. The reproductive organs are developed on different fronds. The fronds bearing the male organs are an olive brown, while those of the female are a reddish brown.

Fig. 1 shows a frond of *Fucus Vesiculosus*, natural size. The pair of air-bladders, which gives the name to the sea-weed, is

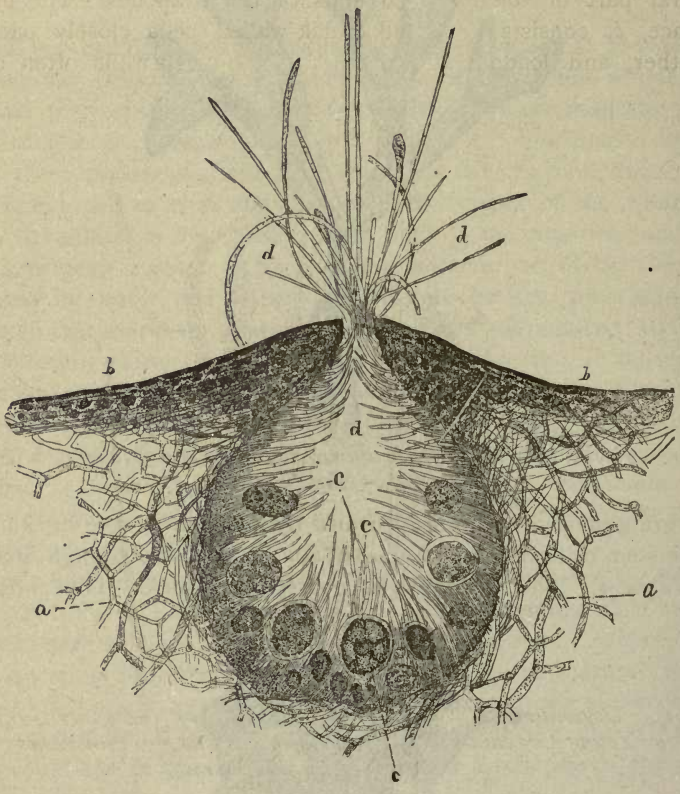


Fig. 3. Conceptacle, F. Vesiculosus. a. Interlacing Filaments. b. Epidermal Cells. c. Oogonia. d. Hairs. (x75 Diameters.)

seen at *a*. Generally all of the tips of the branches are enlarged and bearing, thickly crowded on the surface, the small conceptacles which contain the reproductive organs.

A cross section of the enlarged tip, seen at *b*. fig. 1, was

made, and the little protuberances or black spots on the surface showing at *a* fig. 2 are the conceptacles. There are six of them in the section showing different stages of perfection. The conceptacle in the upper right-hand corner of the illustration was more highly magnified and is seen in fig. 3.

A, fig. 3, are the interlacing filaments which fill up the whole central part of the enlarged ends of the branches. The outer surface, *b*, consists of small, thick-walled cells closely packed together, and loaded with mucilage. The cell-walls often con-

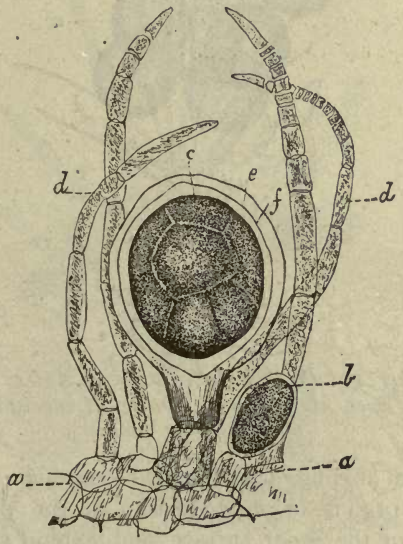


Fig. 4. Oogonium, F. Vesiculosus. a. Cells of the Inner Surface. b. Young Oogonium. c. Protoplasm. e and f. Membranes. d. Hairs. x200 diameters.

sist of two clearly distinct layers; the inner, firm, compact; the outer, gelatinous and capable of swelling greatly in water. These cells can be plainly seen with a magnifying power of 200 diameters, or when the surface of the plant is examined, but not distinctly on a cross-section. The cell contents is granular and has not been well investigated. The contents appear

brown, but contain chlorophyll, which is concealed by other coloring matter.*

We come now to the special object of interest to all botanists in this plant, which is the enlarged bodies found inside of the conceptacle. The whole object in life of these openings, or rather of the plant itself, is to produce, develop, and scatter the

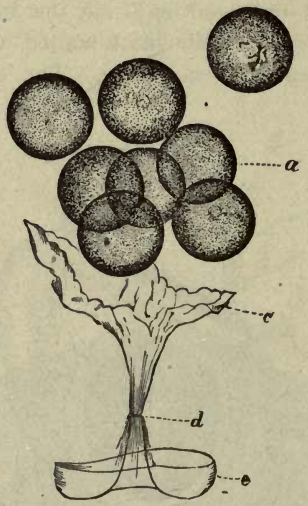


Fig. 5. Oospheres of the F. Vesiculosus. (After Thuret.) a. Oosphere. c. Inner Membrane. e. Outer Membrane. d. Point of Union of c and e.

dark bodies seen at *c*, fig. 3, and called oogonia. They correspond to the female organs of reproduction in the plant. At *d*, the hairs which line the inner surface and extend far out from the mouth of the conceptacle are seen.

Fig. 4 represents one of these oogonia magnified 200 diameters; *a*, cells forming the inner surface of the conceptacle, very thin-walled and filled only with protoplasm; *b*, a young oogonium not fully formed and showing only one sack or membrane covering it; *d*, shows four of the hairs—paraphyses—cover-

*In a recent paper (Comptes Rendus de l' Acad. des Sci., Feb. 22, 1869), Millardet showed that from quickly-dried and pulverized Fucaceæ an olive-green extract is obtained by alcohol, which, shaken up with double its volume of benzine, and then allowed to settle, produces an upper green layer of benzine containing the chlorophyll, while the lower alcoholic layer is yellow, and contains phycoxanthine. Thin sections of the frond, completely extracted with alcohol, contains also a reddish-brown substance, which, in fresh cells, adheres to the chlorophyll-grains, and can be extracted by cold water, more easily when the dried fucus has been previously pulverized. Millardet calls this reddish-brown substance phycophæine.

ing the inner surface of the conceptacle; they are long, nearly transparent bodies containing small quantities of protoplasm; *c* is the nearly ripe oogonium. Two distinct membranes or sacks appear at *e* and *f*. The central mass of protoplasm, as soon as it has attained a definite size, divides itself into eight distinct masses. About the same time that the protoplasm begins to divide, the membrane *e* is ruptured at the top, and the whole mass, with the second membrane, *f*, floats out. The eight

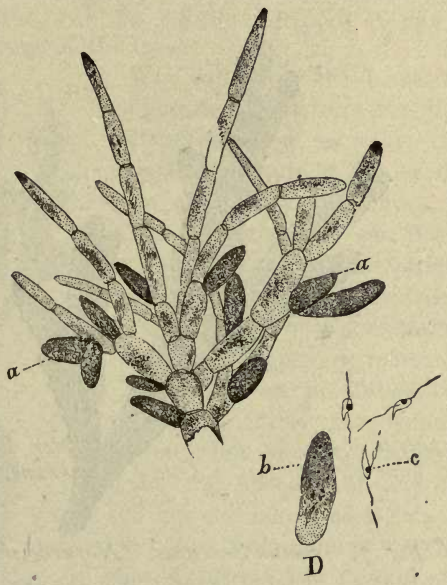


Fig. 6. Antheridia, F. Vesiculosus. a. The Antheridia. b. Some More Highly Magnified. c. Autherozoids. (400 diameters.)

divisions contract upon themselves, forming round bodies until they break through the two remaining membranes, and float out in the water as eight uniform, nucleated, perfect spheres, called oospheres, fig. 5. These are carried out of the conceptacle by means of these hairs, whose only object is to throw the oospheres from the conceptacle.

In the olive brown fronds of the *Fucus Vesiculosus* which resemble the one pictured in every respect, excepting in the

conceptacles, in the place of the oogonia we find little masses of protoplasm growing on the sides of the hairs, rather than at their bases, known as antheridia—or male organs of reproduction—as seen at *a*, fig. 6.

At D, fig. 6, we see one of the antheridia more highly magnified, showing the great numbers of antherozoids as they float in the water; little pointed bodies with a distinct, bright red spot at one side and furnished with two very active cilia, one extending forward and the other back. The antherozoids are fully

Fig. 7. Fucus Serratus. Natural size.

developed at the same time the oospheres are thrown out of the conceptacle; and there seems to be some attractive power in the oospheres, or in the paraphyses around the mouth of the conceptacle, for the moment the oosphere leaves its home it is attacked by swarms of the antherozoids. They seem to attach themselves firmly by means of the anterior cilia, while the posterior is in active motion. In this way they give to the oosphere a rapidly whirling motion, which lasts for nearly half an hour. It then becomes quiet, and very soon a change is seen. It is supposed that the oosphere comes to a rest so soon as an antherozoid forces its way through the membrane into the protoplasm; the primitive change in the oosphere is a semblance

of a cepta, that gradually grows more distinct until it crosses the whole, when one-half of the fertilized oosphere puts out little protuberances which develop into roots, and the other half grows into an expanded frond that developes in its turn conceptacles, oogonia and oospheres, or antheridia, and antherozoid.*

[As a note to the excellent article of Mrs. Stowell's we give plates of the two most common varieties of the sea-wracks that are apt to be substituted for the genuine anti-fat one. The first, or Fucus Serratus, can be readily detected if any attention is paid to the contour of the leaves.

Fig. 8. Fucus Nodosus.
Natural size.

You will notice the leaves are dentated, or serrated, and from this fact it derives its specific name, serratus. It has no air vessels, or bladders, as seen in the genuine obese-reducing Fucus, which gives it its specific name Vesiculosus.

The other common variety, and one most apt to be confounded with the F. Vesiculosus, is the Fucus Nodosus, as seen in the accompanying plate.

This knotted, or clubbed-wrack resembles considerably the genuine medical variety, but can be distinguished from it by the absence of any mid-rib, and the vesicles along each side of the mid-rib. Any enlargement the Nodosus has, that simulates the Vesiculosus variety, is a bulbous enlargement of the whole frond.

The common name, "wrack," which all these species of sea-weed bear, is derived from the Channel Island vernacular, where it is known as *vraic*, a *patois* of the French *varec*, which means "sea-weed." Another vernacular name for the Fucus Vesiculosus is (from its color) "Black Tang."—EDITOR OF LEONARD'S JOURNAL.]

*Authorities—Harvey, Neries Boreali-Americana. Sach's Botany, page 227. Thuret, Ann. des Sci. Nat., Ser. IV., Tom. 2.

Ipecacuanha, Its Structure and Adulterations.

During the course of the year many specimens are sent to the Microscopical Laboratory for examination. The majority of these specimens are the commercial spices, such as mustard, cinnamon, pepper, etc., and the more common, or the more expensive drugs. Among the drugs sent for examination have been

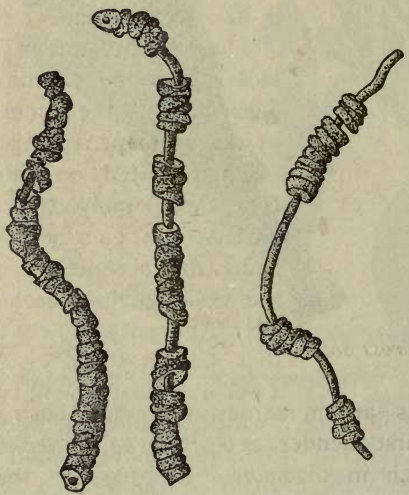


Fig. 1. Roots of Ipecacuanha, natural size.

several specimens of Ipecacuanha. Although this drug is reported by Bentley and Trimen and by Stillé and Maisch as comparatively free from adulterations—frequently having other roots substituted for it—yet the specimens sent here have all been adulterated more or less. Evidently powdered ipecac is losing its reputation for purity and will soon have to be classed

with those drugs and spices commonly reported impure. The substances which were found to be mixed with the ipecac were of the simplest kind and can be detected under the microscope by persons having had no experience in this line of work before. But to understand what belongs to the pure powder one should become acquainted with the physical appearance as well as the structure of the root itself.

The botanical name is *Cephætis ipecacuanha* while the common name is ipecac. It belongs to the natural order Rubiaceæ. It is indigenous to the damp forests of Brazil, New Granada, and the north-eastern portion of Bolivia between about 8° and 22° south latitude. So it is entirely an imported drug.

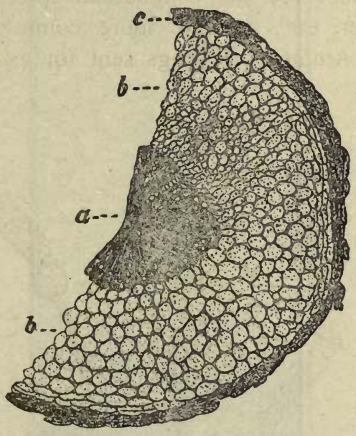


Fig. 2. Cross section of Ipecacuanha root. x 10 diameters.

The roots are numerous, spreading horizontally from their origin. At first slender and white, but when fully grown about 1-5 of an inch in diameter. In preparing the drug for market the smaller roots are discarded, only those of an average thickness being used. They are long, seldom branched, of an orange-brown, or of a dull gray-brown occasionally almost black, irregularly bent and twisted and covered with a very thick bark. There are numerous deep longidutinal furrows running the entire length of the root, transversely marked by ring-like furrows closely packed together. The depressions between the rings being sometimes as deep as the woody cord. These corrugations

frequently number twenty to the inch, and give the appearance of rings strung on a cord, hence the name annulated ipecacuanha, which is applied to this root and by which it is distinguished from the non-officinal ipecacuanhas. The woody cord is about $\frac{1}{20}$

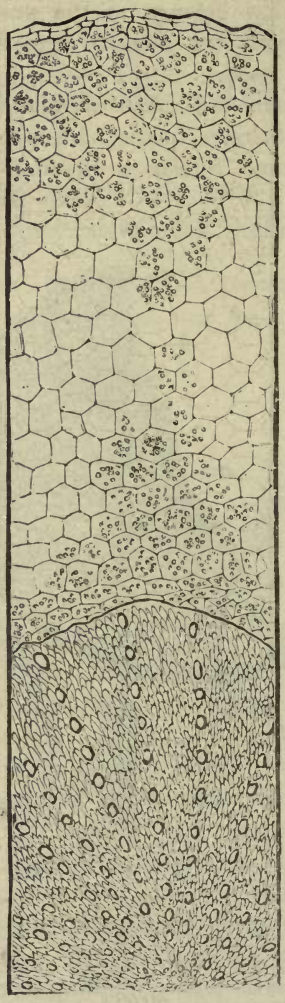


Fig. 3. Cross section of Ipecacuanha root. x 60 diameters.

of an inch in diameter, and when wet shows distinct medullary rays. There is no pith present. The thick bark composes about

three-fourths the bulk and weight of the root, and separates readily from the woody cord.

The roots are collected at all seasons of the year, but principally from January to March. They are dried in the sun and packed in bales. About 15,000 lbs. are brought to the United

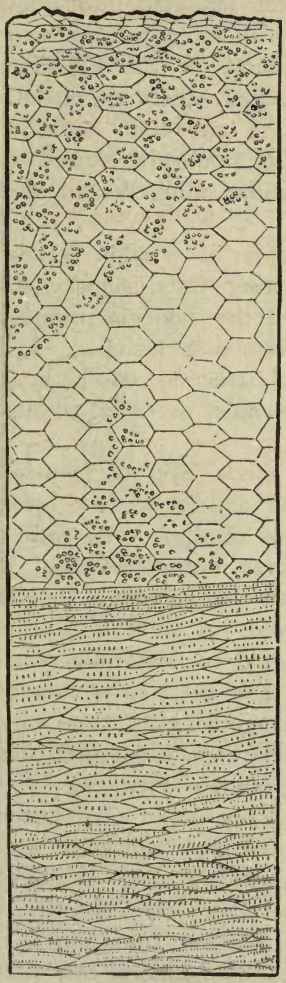


Fig. 4. Longitudinal section of Ipecacuanha root. x 60 diameters.

States annually. Large quantities of the ipecac of commerce are damaged. They are injured by sea-water and by being gathered during the rainy season. The statement has been made that over four-fifths of the ipecac imported into England is damaged. It is also badly mixed with inferior roots both of the same and of other plants. The most of the substituted roots are nearly smooth, and non-annulated, others are medulated, farinaceous, with white woody cords. All are totally different from the true root. Woody stems are also frequently mixed with the roots. The most of these substitutions under the microscope possess a central pith.

Powdered ipecac is of a light yellow-gray color, with a peculiar bitter, nauseating taste, slightly acrid. It has a faint musty odor; much of the odor is probably lost in the drying process. The wood is almost tasteless.

The microscopical structure of ipecacuanha is so characteristic, although quite simple, as to be a sure means of identification.

There is first a single layer of tabular cells, empty, flattened rather thick walled and of a dark brown color. [Some authors give several rows of these cells and call them cork.* But the best authority gives only one row. It is possible in the preparation for market, the epidermis together with some of the cork cells are destroyed. If so it is a little surprising that only one layer of cells should so uniformly remain.]

The principal part of the root is composed of the bark consisting of oval or hexagonal cells, thin walled, with no intercellular spaces. The cells are loaded with starch granules. These starch grains are very minute averaging $\frac{1}{550}$ of an inch in diameter. They are generally found in clusters of two, three or four, so when separated they will have one or more plane faces with the rest of the grain rounded. A minute depression or dark spot appears near the center of a majority of the grains. These starch grains are so different from the starches of the most of those substances used as adulterations, as to be easily distinguished. Some of the cells of the bark are set apart to contain crystals in the place of starch. These crystals are long and

*Planchon, "Determination des Drogues Simples" vol. 1, p. 498, says "seven or eight rows of cells form the outer cork."

pointed at both extremities, and found in large bundles of from twenty-five to forty lying side by side like Indian arrows. When confined within the cell they are never found crossing or lying at angles. They are crystals of calcium oxalate.

The central part is composed entirely of woody fibre, and medullary rays. The medullary rays consist only of nearly square, thin walled cells loaded with starch. They are much smaller, though resembling the cells of the bark. The woody portion consists of thick walled, short, pointed cells, with pitted walls. They are generally empty and it is the only part of the structure not loaded with starch. There is no pith in the center of true ipecac,

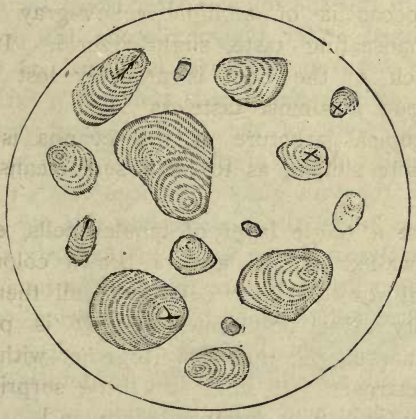


Fig. 5. Potato Starch. x 375.

though there is in the most of the substituted roots. The corticle portion is by far the more active portion of the root. The woody cord being almost inert.

Thinking some of my readers, who have had little or no experience in studying the drugs as they appear in market, so withered and dried, might like to examine ipecac, I will take a moment and help them. A small fair looking piece of the ipecac root should be placed in a dish of cold water for from ten to twenty hours—warm water for a short time will do, though it should not be boiling. Then with a sharp razor a section should be cut across the root just as thin as possible. There is no necessity of cutting the section complete, *i. e.*, having the

whole of the root in the section. Only a very minute piece is needed, that will show both the bark and the woody center. Probably several sections will have to be cut before one will be thin enough. Float this little section on the glass slide with a camel's hair brush. Holding the little piece in its place on the slide with a needle—the needle should have been wedged into a wooden handle for convenience—wash the specimen in water many times with the camel's hair brush, so as to remove as much as possible of the starch. The longitudinal section should be prepared in the same way. In cutting the longitudinal section care should be taken to cut near the center, so as to have some of the woody cord in the specimen. After these sections have been thoroughly examined under the microscope, the powdered ipecac can be studied. A drop of water is placed on the glass slide by means of the camel's hair brush and just a little of the powder taken on the point of the penknife and dusted over the water—only a small amount of the powder is to be taken. After protecting it with the thin glass-cover it is ready to be examined. Any one who has taken these steps, can test for themselves the purity of the powdered ipecac found in the drug stores.

The following substances are reported as having been found in powdered ipecacuanha: almond meal, licorice, corn meal and potato starch.

The presence of almond meal can be detected by the development of hydrocyanic acid upon infusion in water. The presence of the seed coats as well as the central part of the almond may be detected by the microscope. The central part or the cotyledons are composed of thin walled hexagonal cells, smaller than the cells of the bark of the ipecac, and loaded with oil drops. They are entirely free from starch grains. Minute spiral vessels are frequently scattered through these cells. The outer seed coat or the dark brown scurfy part of the almond is made up of large oblong cells, with peculiar pits or dots covering the cell-wall. They are about $\frac{1}{500}$ of an inch broad and nearly twice as long. By the way, if some of these cells are scraped off from the outer surface of the almond and boiled in a solution of caustic soda they will make beautiful objects for examination with polarized light under the microscope. Almond meal is probably not of very common use for mixing with ipecac.

A prominent druggist in one of our western cities told me he had found quite a large per cent. of the powdered ipecac, that was sent to him from the east, to be mixed with powdered licorice. The only way to become acquainted with the appearance of licorice under the microscope is to prepare and examine some of the root in the same way we prepared and examined ipecac root, and then to study some of the powdered licorice. This would hardly be necessary for the identification of licorice when it can so easily be detected by its taste and odor.

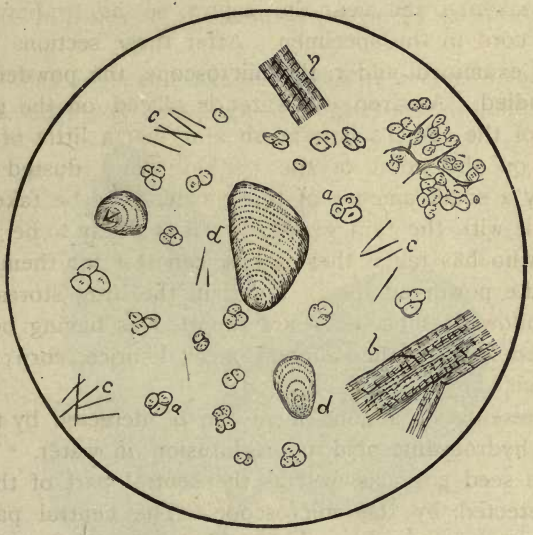


Fig. 6. Powdered Ipecac. a, starch grains of ipecac. b, woody fibre. c, crystals. Adulterated with d, potato starch. x 375

By far the most common substance used is potato starch. Of all the specimens of powdered ipecac which I have examined, every one had more or less of potato starch mixed with it. Only two having corn meal. Potato starch grains are so very characteristic that it would be impossible for any one to mistake them under the microscope for the starch grains of ipecac. In fig. 5 is given an illustration of the starch grains of potato. Large, oval, or irregularly ovate grains. Each one possessing a nucleus

or spot around which is seen numerous rings. Frequently these are as large as $\frac{1}{400}$ of an inch in length. A very simple way for obtaining some of these starch grains for study is to cut into a potato, and the fine white powder adhering to the knife will be the starch, or if a thin slice of the potato be shaved off and placed in a little water in a watch crystal the fine white sediment found at the bottom will be the starch. Fig. 6 illustrates some powdered ipecac adulterated with potato starch.

Boldo Leaves.

THE boldo leaves of commerce are gathered from the shrub or tree, Boldoa fragrans, which belongs to the natural order Monimiaceæ. This tree is a native of Chili, found growing luxuriantly on the hillsides of the central provinces and cultivated in gardens.

It is a tall, evergreen, diœcious shrub or tree, with verdant foliage, fifteen to twenty feet high—though some authors give the

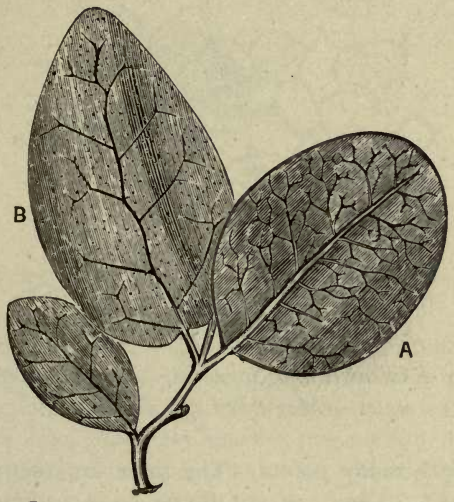


Fig. 1. Boldo Leaves.—A, lower surface. B, upper surface. Natural Size.

height as only from five to six feet. The flowers are sweet-scented and of a greenish-yellow color. The fruit is small, about the size of a pea, sweet, aromatic and of a yellow color, which the natives used as a relish. It is used though in small quantities on account of the sensation of heat left in the mouth and the almost sickening sweetness of the fruit.

The leaves are opposite and borne on short petioles. They are oval, obtuse at both apex and base, coreaceous, strong and rough. The lower surface of the leaf, fig. 1, *a*, is marked by prominent midrib and veins, even the minute net-work of veins showing. The hairs add to the roughness of the lower surface. The upper surface, *b*, is more glossy and is thickly studded with small whitish projections. The dried leaves have a reddish-brown color with a fragrant odor and a refreshing aromatic taste. The lower surface of the leaf, when examined with the microscope, is found to be composed of the usual epidermal cells, see *a*, fig. 2, quite uniform in size and appearance, while the stomates *b*, are like those of other leaves. Each stomate, however, is surrounded by four epidermal cells. The hairs found on the under side of the leaf are not very numerous or uniform in size or appearance. They are multicellular

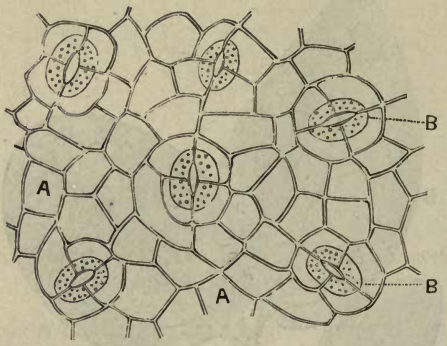


Fig. 2. Lower Epidermis and Stomates.—a, Epidermal Cells. b, Stomates. Magnified 350 Diameters.

and stellate with many points. The same are seen in fig. 3 more highly magnified. They are not borne on a pedicle or stem, but directly from the lower epidermis, as seen at *a*, fig. 4. The hairs found on the upper surface of the leaf are unicellular, long, slender, and borne on an enlarged multicellular base, formed only of epidermal cells. These hairs are so easily brushed off the leaf that in the commercial leaf the projections are generally found without the accompanying hairs.

Fig. 4 represents a cross section of the leaf, showing the relations of the projections and hairs to the rest of the leaf. One can

easily see here that the roughness of the upper surface is due only to the enlarged bases of the epidermal hairs. The portion of this

Fig. 3. Epidermal Hairs.—From the Lower Surface of the Leaf. Magnified 200 Diameters.

section seen at *c* was more highly magnified and represented in fig. 5. The upper surface of the leaf is furnished with two rows of thick walled epidermal cells, which is unusual, as leaves have generally only one row. Directly beneath these is found the usual row of elongated palisade cells, *b*, filled with chlorophyll. In a dried

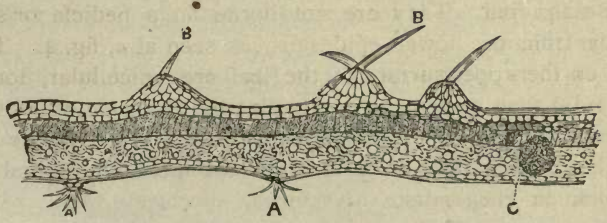


Fig. 4. Cross Section of Leaf.—a, Stellate Hairs on the Lower Surface. b, Unicellular Hairs on the Upper Surface. Magnified.

specimen the chlorophyll is of a yellowish-brown color. Forming the central part of the leaf are the loosely packed cells, called parenchyma, loaded with brown coloring matter and dead protoplasm. The lower surface of the leaf is protected by a single row of thick-walled epidermal cells, similar to those of the upper surface. Numerous large glands *e* are found scattered through the loose parenchyma. In some of these are pendant cystoliths, *d*, others contain the essential properties of the boldo leaf, as boldina, tannin, and aromatic resinous compounds. There are smaller oil cells,

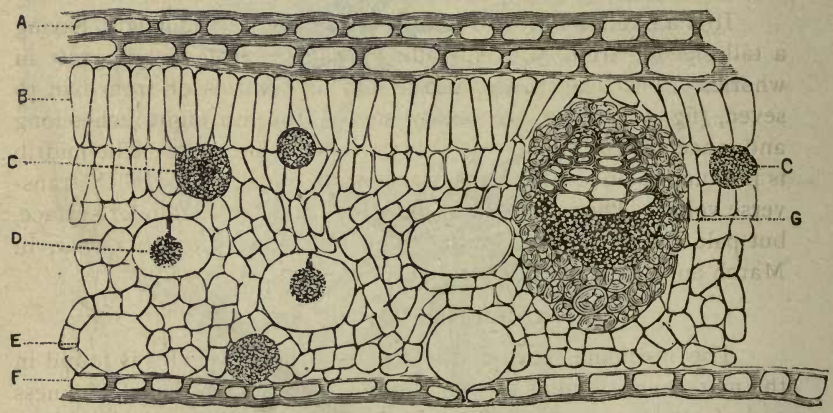


Fig. 5. Cross Section of Leaf.—a, Upper Epidermis. b, Palisade Cells. c, Oil Cells. d, Cystoliths. e, Glands. f, Lower Epidermis. g, Vascular Bundle. Magnified 350 Diameters.

c, scattered through the leaf, sometimes found even between the palisade cells and the upper epidermis ; these are loaded with essential oil. At *g* is seen a cross section of one of the veins of the leaf.

Boldoa fragrans is recognized by both the French and the Germans as officinal.

Travelers inform us that it has been used by the natives of Chili from time immemorial. In 1870 the medical men of Chili first began to use it in their practice. Shortly after it was introduced into the United States. It is now recommended for use in liver troubles, in rheumatism, dyspepsia, ulceration, etc., while it is receiving some notice as a curative agent in yellow fever.

Alstonia Scholaris.

ALSTONIA SCHOLARIS is found in India, in the tropical islands and in Northern Africa.

It is a handsome forest tree from 50 to 80 feet in height, having a tall slender trunk with spreading branches that always grow in whorles. The leaves are also found in whorles of from five to seven, (fig. 1). They are nearly sessile, four to eight inches long and lanceolate or oblong with bluntly acuminate ends. The midrib is prominent on the lower surface, with numerous parallel, transverse veins. They are of a bright green color on the upper surface, but pale and dull on the lower. The tree flowers twice a year, in March and December.

DESCRIPTION OF THE BARK.

The medicinal part of the tree is the bark. This is found in the market in irregular pieces from $\frac{1}{8}$ to $\frac{1}{2}$ an inch in thickness and of a spongy texture. The external surface is rough and uneven and of a grayish-brown color, with numerous cream-colored patches that flake off like scales. The inner surface is mealy in consistency, and of a bright yellow color. It is of no particular odor, and its taste is purely bitter, neither aromatic nor acid.

MICROSCOPICAL STRUCTURE.

The outer layer of the bark is composed of from eight to twenty rows of tabular parenchyma. The cells are thick walled and empty (see *a*, fig. 3). The cellulose of the walls is colored a deep amber. As a dividing line between this structure and the next, that is, between the outer and middle layers of the bark, is found a delicate texture, consisting of three or four rows of clear white empty cells (*d*, fig. 3). This outer layer is called the cortical layer by some authors.

The middle layer of the bark, which is the principal part of the whole specimen in bulk (*b*, figs. 2 and 3), is composed of loosely

packed oval cells, with masses of enormous, bright yellow stone cells, scattered thickly through the layer (fig. 3, *e*). They are so numerous as to be seen with the naked eye, and they give the mottled appearance to the outer part of this layer of the bark. These stone cells (or *sclerenchyma*) are much smaller toward the

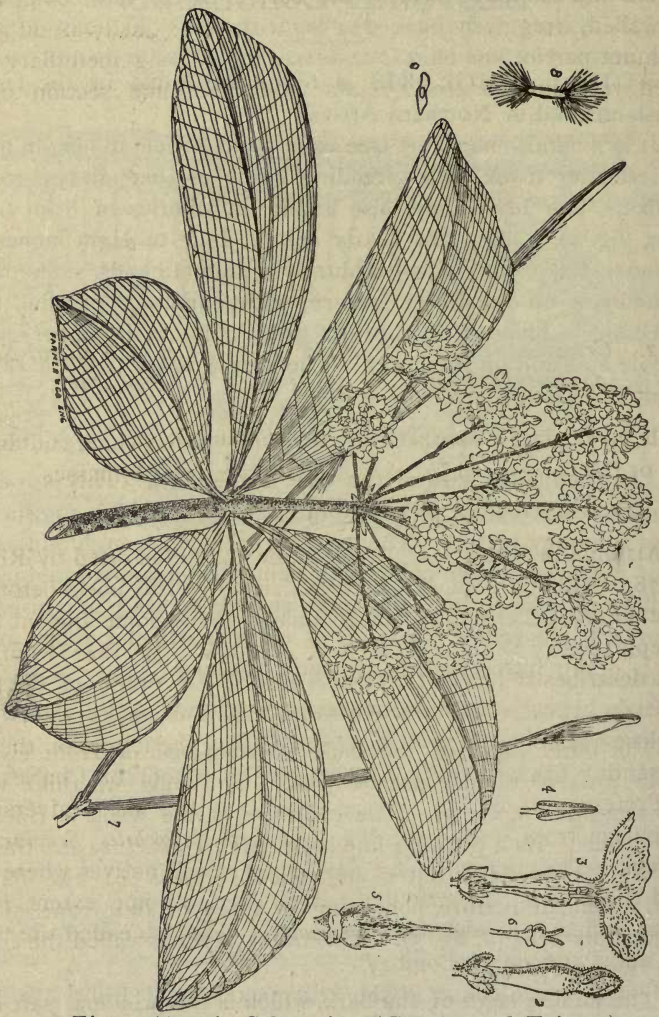


Fig. 1. Alstonia Scholaris. (*Bentley and Trimen.*)

inner bark, though they do not disappear entirely. Many of the cells of the middle bark contain beautiful crystals of calcium oxalate. Found much more numerous toward the outer edge (*f*, fig. 3). Some of the cells are enlarged and filled with oil or the essential properties of the plant.

We find the inner layer of the bark is narrow and composed of thin walled, irregularly packed cells, with occasionally an oil gland. The inner part of the bark is traversed by waving medullary rays, loaded with minute starch grains. A longitudinal section of the

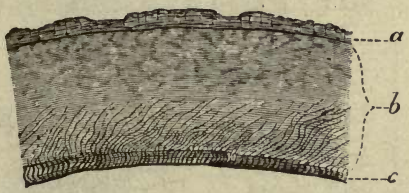


Fig. 2. Cross Section of Dita Bark. Three times its Natural Size.—a, Outer Bark. b, Middle Bark. c, Inner Bark.

middle layer gives a few large laticiferous vessels, which contain the latex or the concrete juice of the tree—in brownish masses.

HISTORY.

Alstonia Scholaris was first described and illustrated by Rheede in 1678. Although its praises were sung by the poets before the Christian era, according to Dr. Rice, who found some ancient Sanskrit epic poetry on the subject of Alstonia. In 1841 Rumphius again describes the tree and gives the probable origin of the name *Scholaris*. It seems the school children used to make slates from the close-grained wood of this tree, making the letters on the slab with sand. The plant is named Alstonia in honor of Charles Alston, Professor of Botany and Materia Medica in the University of Edinburgh from 1740–1760. It was named *Echites Scholaris* by Linnæus. The common name among the island natives where it is found is *Satween*. In the Philippines and to some extent in the United States, it is known as Dita Bark. It is also called the "devil tree" and Palimara of Bombay.

The drug is officinal in the Pharmacopœia of India. It is not employed to any extent in Europe, and is not recognized in either

the British Pharmacopœia, or in the U. S. Dispensatory. Descriptions are given of it, however, in Bentley and Trimen's Medical Plants, No. 173; in Flückiger and Hanbury's Pharmacographia, page 421 (new edition), and in the National Dispensatory, page 140.

There is a large tree of Alstonia Scholaris growing now in the royal gardens of Kew.

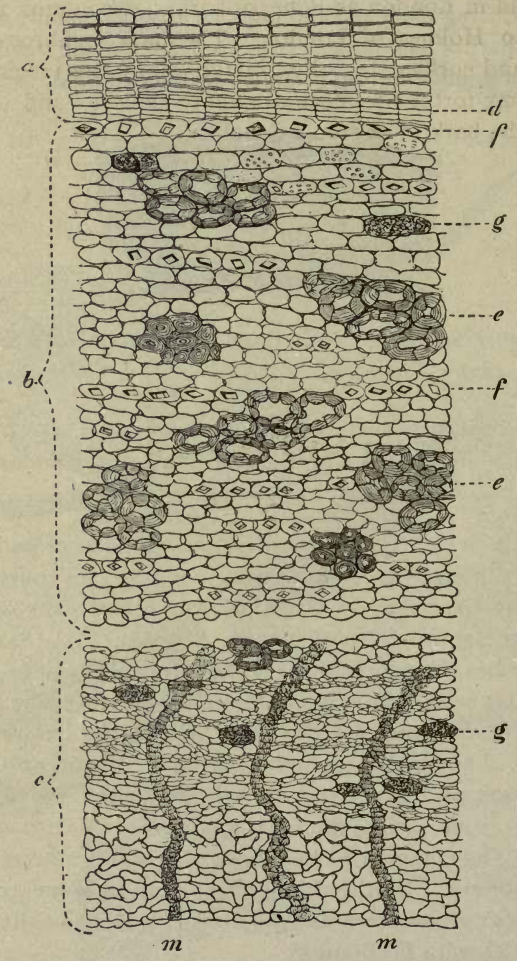


Fig. 3. Cross Section of Dita Bark.—a, Outer Bark. b, Middle Bark. c, Inner Bark. f, Crystalls. e, Stone Cells. g, Oil Glands. m, Medullary Rays. x70 diameters.

It possesses strong tonic and antiperiodic properties, and is ardently recommended by many as a substitute for quinine.

ALSTONIA CONSTRICTA.

Closely related to this drug is Alstonia Constricta, called the Australian fever-bark. It is occasionally imported from India, and has been sold in London as Bebeeru bark. It contains no alkaloid, according to Holmes of London. The bark is fibrous internally and rough and corky externally, though all of the specimens which it has been my fortune to meet are more delicate and of a lighter color than the bark of Alstonia Scholaris.

FOLIA CAROBÆ---JACARANDA CAROBA.

THE Caroba leaves of commerce are obtained from a native tree of Brazil. It belongs to the family Bignoniaceæ, and has been honored with a number of names. The correct one probably is Jacaranda Caroba, given it by De Candolle; although the name Jacaranda Procera, given by Sprengel, is in quite common use.

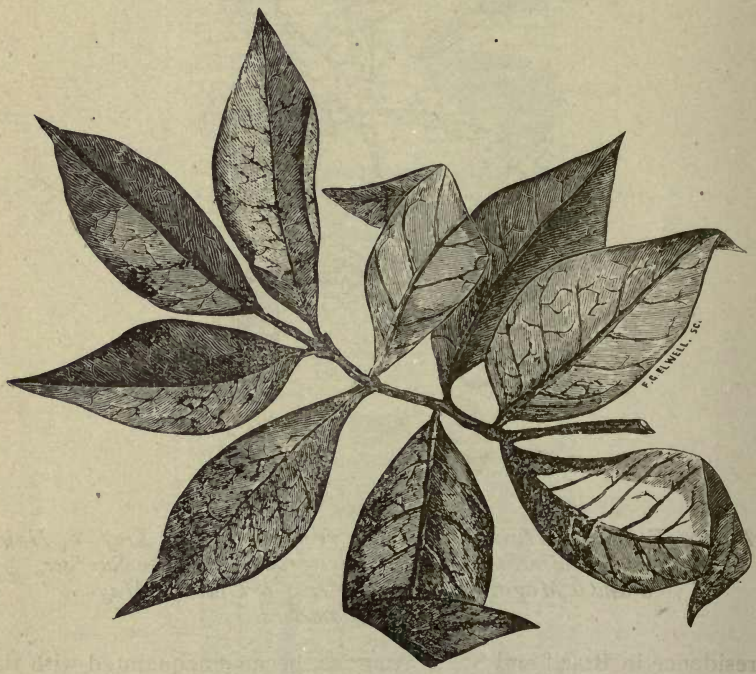


Fig. 1. Jacaranda Caroba. One Branch of a Compound Leaf. A Pinna or Leaflet. Natural Size.

Martins called the tree Cybistas Antisyphilitica, and Vellos gives it the appropriate title of Bignonia Caroba.

The medicinal properties of the tree are found principally in the leaves, and their beneficial effects have been known for a long time to the native doctors of the aborigines of Brazil, and it has been used extensively by the Brazilian physicians. John Alves de Canerio, an eminent physician, submitted it to the Academy of Medicine at Paris, and from this introduction it was described in the Materia Medica. Mr. Camillo Weber, a licensed apothecary of Leipzig, Rio de Janeiro and Montevideo, during his sixteen years

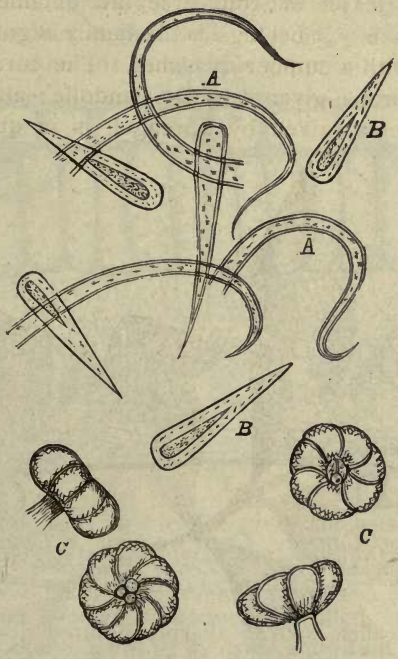


Fig. 2. Epidermal Hairs and Glands from the Caroba Leaf. a, Hairs from the Under Surface. b, Hairs from the Upper Surface. a and b Magnified 100 diameters. c, Glands. Magnified 500 diameters.

residence in Brazil and South America, became acquainted with the extensive use which the resident physicians made of the Caroba leaf. By his recommendation it was introduced into Hamburg by J. Von der Heide, apothecary.*

*Dr. Ottoker Alt. Hamburg,—in the Pharmaceutical Zeitung, Bunzlau, Berlin.

The tree grows to a height of from 30 to 40 feet. The root is externally of a dark red, internally of a yellowish white color. The flowers are red and white in showy terminal cymes, and they have an agreeable honey-like flavor; the fruit is a woody bivalved capsule, containing several winged seeds. The stems are considerably branched and produce large compound leaves. The beautiful dark green leaves are bipinatified, being divided into from six to eight pinnæ, while each pinnæ is divided into from eight to twelve pinnules or leaflets. The illustration represents only one branch or pinna of the leaf (see fig. 1). The leaflets toward the end of the pinna are seen on the upper side, while the under side shows in the

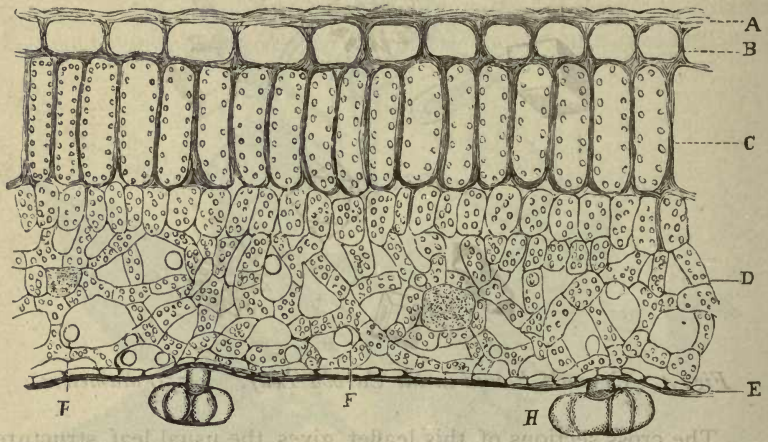


Fig. 3. Leaflet of Carobа. Cross Section. a, Cuticle. b, Epidermal Cells. c, Palisade Cells. e, Lower Epidermis. f, Oil Drops. h, Epidermal Glands. x 500 diameters.

others. Each leaflet is oval, sharply pointed at the apex and the base, and with a smooth border. The upper surface of the commercial leaflet is dark brown and smooth, while the lower surface is much lighter in color, and with strongly marked midrib and veins; and is wooly on close inspection. The wooliness is caused by the presence of numerous long, slender and empty hairs (see *a*, fig. 2). The hairs are of an unusual length and thickly covered with minute projections of cellulose.

There are only a few hairs found on the upper surface of the leaf. They are much shorter, broader and only faintly marked with projections. (See *b*, fig. 2.)

There are in addition to these hairs some beautiful glands thickly scattered over the leaf surface (see *c*, fig. 2). These are wheel-shaped, and composed of eight or ten cells. In the dried leaf they are of a reddish brown color, and probably contain oil and some of the essential properties of the leaf. Similar glands are found on the surface of a few other kinds of leaves, and they generally contain "secreted resinous, gummy or other substances."*

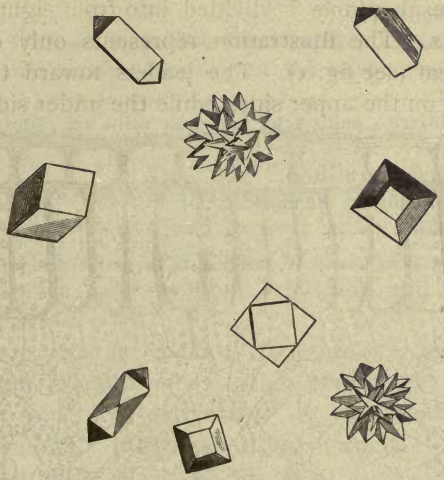


Fig. 4. Crystals Found in the Caroba Leaf. x 750 diameters.

The cross sections of this leaflet gives the usual leaf structure (see fig. 3). A thick cuticle protects the leaf on the upper surface (*a*). The epidermal cells (*b*) are unusually large. Directly beneath these are the long slender palisade cells, filled, when fresh, with bright green chlorophyll; but in its dried condition filled only with dead brown chlorophyll bodies. The lower half of the leaf is composed of the usual loosely packed parenchyma (*d*) with occasionally drops of oil and grayish colored, granular masses. The lower epidermis (*e*) is much more delicate, while the cells are either collapsed or are smaller, and the cuticle is thinner than the corresponding parts on the upper surface of the leaf. Two of the large epidermal glands (*h*) are yet attached to the lower epidermis.

A chemical examination of the leaf has been made, with the

*See Bessy's Botany, p. 96.

following results.* In 1,000 grammes of air-dried leaves there were contained:

Carobina	1 620
Crystallic carobic acid	0.040
Crystallic carobic, sebacylic acid	1.000
Carobon (balsamic resin)	26.666
Neutral resin—not perceptible to taste or smell	33.334
Chlorophyll and vegetable wax	9.000
Extractive matter	10.550
Extractive matter, tartaric, lactic and oxalic acids	10.000
Malic acid and calcium	0.200
Tannic acid	4.390
Albumen, dextrin, malic acid, inorganic salts, etc., fibrine and water	885 010
Balsam (extractive matter)	14 420
Substance resembling humus	0.890
Bitter substance	2.880

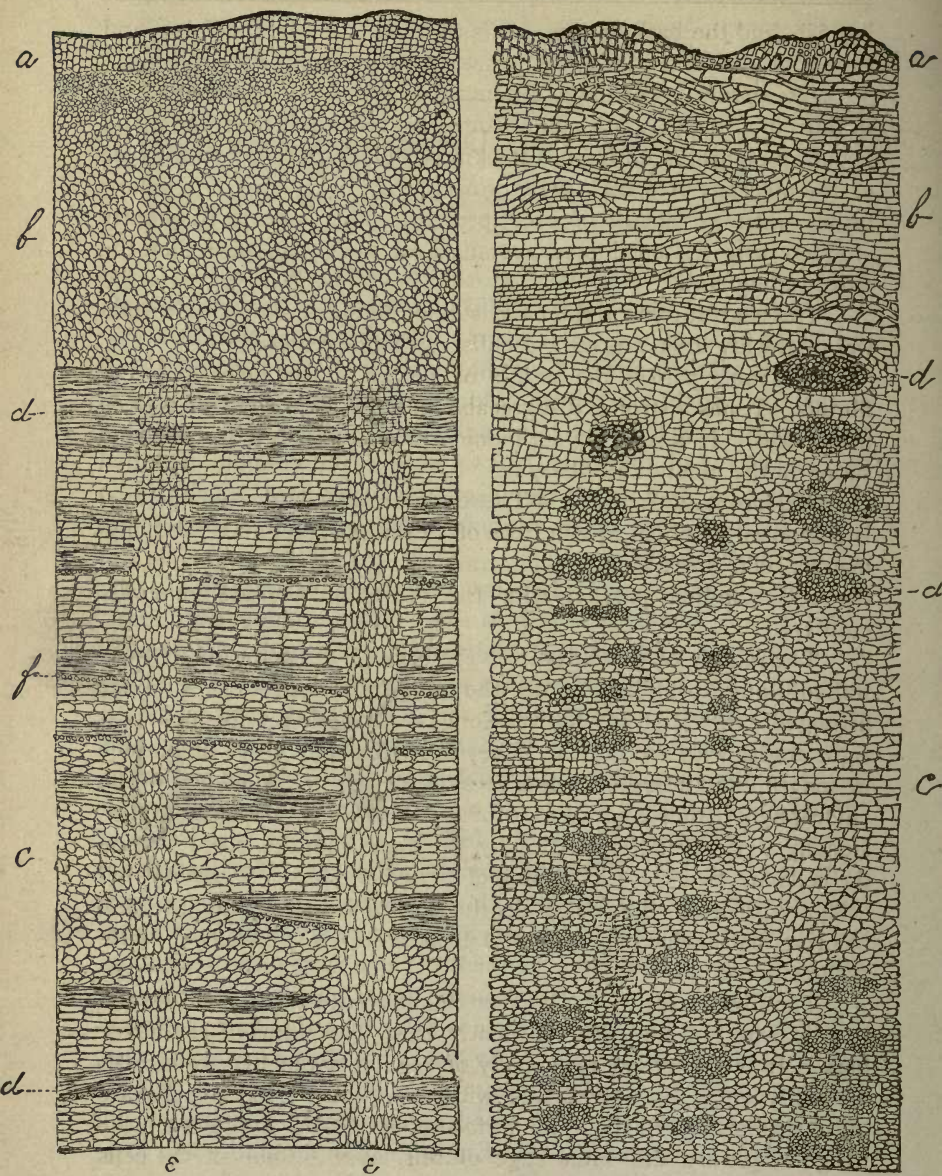
*This report was given by Charles W. Zaremba, M. D., in the Therapeutic Gazette of February, 1880, p. 34.

JAMAICA DOGWOOD--PISCIDIA ERYTHRINA.

FOR a long time all that was known regarding this plant, was the fact that the natives employed the bark of the root for taking fish in some of the larger rivers; hence its name piscidia erythrina—from piscis, a fish. A certain quantity of the powdered bark of the root would be thrown into the water with the certainty of stupefying or narcotizing a large number of the fish. These would float on the top of the water, and so were easily caught. It killed the smaller fish and sometimes even the larger ones. Fish caught in this manner were eaten without hesitation and were not considered unwholesome.

The common name is Jamaica Dogwood; at one time it was called Linné Erythrina Piscipula—the "fish-catching coral-tree," and it has been sold quite extensively in Brazil under the name of mulungû or murungû. It belongs to the natural order Leguminoseæ. It is found in the islands of the West Indies, and is indigenous in the Antilles, where it is extensively distributed, flourishing chiefly in the lowlands, and on calcareous and volcanic soil in the vicinity of the coast. It is found most frequently in Jamaica. It is a small tree, of about twenty feet in height, of very irregular spreading branches, with long compound leaves. The leaflets are opposite, three or four paired, with an odd one. They are oblong or elliptical, rounded at the base, entire, somewhat coriaceous, about two inches long and quite pointed. When young the leaves are covered on both surfaces with minute hairs, but when old they are nearly smooth. The lower surface is paler than the upper, and covered with minute white dots. The leaves are shed early in the year, and previous to the development of the new foliage the flowers make their appearance. The wood is considered valuable, being very heavy, and resembling our English oak in durability and firmness.

The pulverized bark of the root is the part employed in catch-



Jamaica Dogwood. A, Longitudinal Section. B, Cross Section. a, Outer Bark or Cork. b, Middle Bark, or green layer. c, Inner Bark, or liber layer. d, Liber Bundles. e, Medullary Rays. f, Crystals. x 37 diameters.

ing fish, and the bark of the root is the part used in medicine, and should be gathered during inflorescence, otherwise it is unreliable.

Description.—The bark of commerce appears in pieces of two to four inches in length, and from one to two inches wide, and about an eighth of an inch in thickness. The outer surface of some of the pieces is of a dark grey brown, while others are of a yellow brown with no shade of grey present. The bark is frequently studded with flattened protruberances of a lighter color than the surrounding cork.

The central part of the bark is much lighter colored, and when wet or freshly broken is of a peculiar blue-green color.

The inner part of the bark is of a dark brown color and very fibrous. It has a strong, disagreeable odor of opium when broken into pieces. It is strongly acrimonious and produces a burning sensation in the mouth and pharynx.

Microscopical Structure.—The cork or outer bark (see fig. 1, *a*) is composed of about fifteen rows of thin-walled, regular, parenchymatous cells, brick shaped, and arranged radially, *i. e.*, the length of the cell standing parallel with the radius. They are generally empty.

The middle or green layer of the bark (*b*) is composed of thin-walled, long, oval cells. In the longitudinal section they are arranged tangentially, *i. e.*, the longest diameter of the cell is at right angles with the radius. They average about 1-250 of an inch in length, and about one-fourth as wide, containing clear white chlorophyll bodies and dead protoplasm and chlorophyll. Occasionally a crystal is found as if by accident. In the cross section the cells are oval or round and of irregular sizes. Sometimes oil cells are present. The cell walls themselves seem to have absorbed coloring matter, for they are not a clear white as is usually the case with cellulose.

The inner layer of the bark or the liber layer (*c*) constitutes the principal part of the bark, frequently being four-fifths of the whole bark. It is composed principally of regular parenchymatous cells of nearly equal diameters, and with thin walls. These cells are quite regular toward the inner surface of the bark, and grow more irregular toward the outer edge of this layer. Some of the cells show pitted marks, which are deposits of cellulose on the cell walls.

Bundles of liber fibre are arranged in concentric rings through

this part of the bark, hence its name liber layer. On a cross section (see fig. 1, B) these fibres are composed of hexagonal cells with very thick walls, having only a spot or a central line for an opening. On a longitudinal section the fibres are frequently 1-10 of an inch in length. These long cells of the liber fibre give the fibrous structure to the inside of the bark. On either side of the bundles of liber fibre are rows of polyhedral crystals of calcium oxalate.

Medullary rays, composed of regular brick-shaped cells similar to those of the cork, are seen travesing this layer. This part of the bark contains, besides the liber and crystals of calcium oxalate, some oil ducts and resin glands,—apparently different in no respect from the surrounding cells,—some small scattered laticiferous tissue and separate oil drops.

Physiological Action.—It is said to be a "cerebro-spinal drug, expending its influence almost entirely upon the nervous system. It causes at first an increased activity of the cerebrum. This is shortly followed by a dazed feeling. There is a violent itching pain in the upper portion of the medulla oblongata, with nervous trembling."

It causes burning soreness in the eyes and heat in the internal structure. The eyes look wild and staring and there is a constant movement. There is excoriation in the nares posteriores with sneezing and coryza. There is also an aching pain in the temples. It induces labored breathing, and gradually the whole body comes under its influence. There is an intense excitation of the nervous system, causing a hot flush over the entire body, the pulse is increased ten or fifteen pulsations, with pain in the heart and restlessness, which, however, is quickly succeeded by obliviousness.*

"Experiments upon animals have demonstrated the power of this drug in large doses, to produce prompt paralysis of the motor nerves, while it does not affect the great centers of innervation—cerebellum and medulla,—the great sympathetic nerve or the smooth or non-striated muscular fibre, neither does it affect the seat of intelligence, the heart rhythm, the temperature, or the peristaltic action."†

Properties and Uses.—Dr. William Hamilton, of England, speaks of this plant as a powerful narcotic, capable of producing sleep and relieving pain in an extraordinary manner.

*George William Winterburn, M. D.

†Prof. Fernando Altamarano, M. D., of Mexico.

"In Brazil it has an established reputation as a nervous sedative. Its action seems to be over the nervous centers; it causes sleep without producing the cerebral hyperæmia, nausea and nervous disturbances, which succeed opium and morphia. The sleep is tranquil and refreshing; it soothes bronchial cough and moderates the paroxysm of asthma and nervous coughs."‡

The active principle is a resinoid, soluble only in strong alcohol.

The dose is from 30 drops to two fluidrachms. It is applied externally as well as given internally.

Its most valuable therapeutic use is assuaging nervous pain and producing sleep.

‡C. H. Hanson. M. D.

USTILAGO MAIDIS.

THE question of the substitution of what is known as corn ergot for that of rye, is one of some interest just at present, on account of the cheapness and ease with which the corn ergot can be obtained. It is not properly called corn ergot, for it does not belong to the same family as the rye ergot—*claviceps purpurea*, and is like

Fig. 1.

rye ergot only in its action. It is nothing but the smut which destroys such large quantities of corn, and is known scientifically as *Ustilago Maidis*. Its substitution for *claviceps purpurea* is something

quite recent, and so has very little history. It is not recognized by the U. S. Pharmacopœia.

It is found as a smut growing on almost all parts of corn. The stem, the leaf, the flower, the fruit alike are troubled with this plague. It seems to prefer for its host only tall, healthy plants, and everywhere it takes the most spacious room for its accommodation. It first attacks the summit of the plant or the anthers, and then gradually spreads until the whole plant above the ground is affected. It has never been found in the ovary or the walls of the ovary of the pistillate flower, or in the staminate flower of the Zea Mays; but it is found in every other part of the plant. (See Ann. des Sci. Nat. Vol. VII, Ser. III, page 85.) As soon as the fruit is attacked the

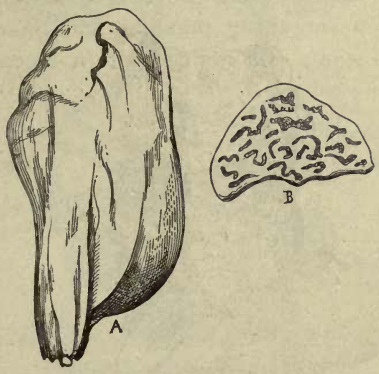


Fig. 2.

outer wall begins to swell out in a most wonderful and grotesque manner, sometimes the affected kernel will change from its natural size to that of the fist. It occasionally turns to a deep red, and if broken gives out a sooty fluid having a somewhat bloody appearance. As it grows older this mass looks like a finely pulverized black soot, with the parenchyma and the vascular woody fibres yet present in the powder.

Fig. 1 represents an ear of Indian corn affected with *Ustilago Maidis*. The disease has affected the whole ear in such a way that it can never develope into healthy fruit. The little bracts on the affected part are tumified by the presence of the smut, and are developed in the most abnormal shapes. The whole outer surface is

covered with openings or blotches, where the spores have broken through, and the outside very much darkened by their presence. Almost every one is so well acquainted with the appearance and growth of this smut that it is not necessary to enter at any length into the details.

Fig. 2 represents one of the bracts alone, with a cross section of the same, showing how the internal structure of the bract is changed from its normal appearance, and is packed full of the fine spore dust.

In fig. 3 we have the spores of the Ustilago Maidis; they are almost as light as the air, and can be carried for a great distance by the wind, the whole outer surface of the spore is covered with minute spines or thorns; they are of a dark-brown color, nearly opaque, and have a singularly pungent and offensive odor. The protoplasm of the spores is contained within a central cell or sack;

Fig. 3. 900 Diameters.

each spore has two surrounding membranes, the inner thin and nearly transparent, while the outer is dark-brown and roughened. At *b* we see a filament or little root just developing from one of the spores. This delicate root works its way into the tissue of the stem, leaf or some part of the corn, and continues to grow until a perfect net-work of roots is made; then after some intermediate steps there develops the great mass of spores which constitute the so-called corn ergot. On account of their extremely thick walls, it is hard to check or destroy this disease.

When *Ustilago Maidis* appears in its natural condition in commerce, it is a mixture of almost everything pertaining to blighted corn, corn smut, powdered corn leaves, etc., even frequently containing the powdered cob. When the greater part of the coarse

material is taken out and the remaining fine powder examined, we find, besides the great quantities of spores, specimens showing the minute structure from almost every part of the corn, and even of many of the neighboring plants.

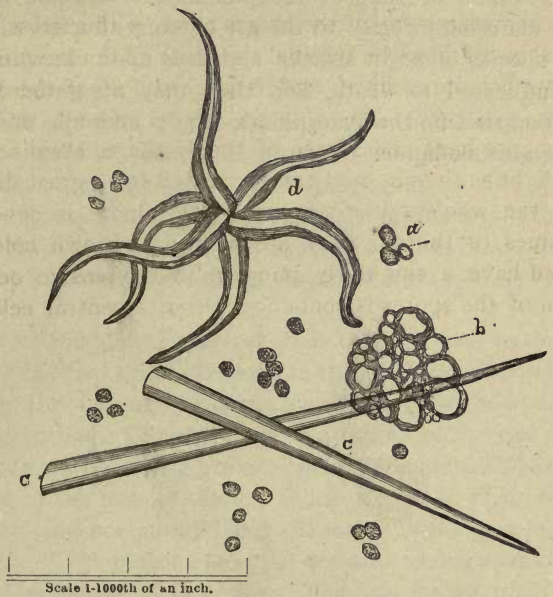


Fig. 5. Commercial Ustilago Maidis. x 250.

In fig. 5 we have a representation of the fine powder as it is sold in the drug stores. There are found in this powder many things that do not belong to Ustilago Maidis. The characteristic spores (*a*) are found in great quantities everywhere. The long slender hairs seen at *c* are the minute hairs found on the surface of corn leaves, and which give the roughness to the leaf; they are commonly present in the powder. At *b* is seen a fragment of the woody part of corn, or more properly speaking, a cross section of a vascular bundle. At *d* we see a stellate hair which is quite characteristic of some of the weeds growing along the road-side and in the fields. Very frequently we find the spores of other parasites mixed with the ergot, such as rust from wheat, onion smut, blight on fruit trees, etc.

Ustilago Maidis is not only destructive to corn, but dangerous to the animals that live on the corn so affected. The death of animals has been traced directly to corn stalks badly affected with smut, and it is said that mules, fed upon corn thus diseased, lose their hoofs. Some of the severe epidemics of Europe and Asia have been charged directly to the use of corn affected with Ustilago. One species of ergot attacks and lives upon caterpillars until they are suffocated to death, and then they are gathered by the Chinese, who grind up the caterpillars, ergot and all, and deal it out as a popular medicine.

Commercial Fibres.

Cotton consists of the down or fine cellular hairs attached to the seeds of plants belonging to the genus *Gossypium* and to the natural order *Malvaceæ*. It is indigenous to all of the inter-tropical regions. These plants supply the raw material for one of our greatest industries, and for the clothing of all nations, and certainly may claim a recognition among the most valuable of nature's production.

The cotton plants cultivated in the new and in the old world constitute the two great divisions in the commercial cottons, and are known as the Oriental and the Occidental, or the Indian and the American cottons. The seeds of the Indian cotton are never black and are always covered more or less with epidermal hairs, and the curvature at the base of the leaf lobes is compounded of two opposite curves, and not purely heart-shaped as in the case of the American plant. "The cottons most in demand among manufacturers of the world, are those of America. The Sea Island plant in the soft maritime climate of the low-lying islands off the coast of Georgia, where frost is scarcely known, has surpassed all other descriptions of cotton in the strength, length and beauty of its staple."*

The stalks of the cotton plant are made to answer some valuable purposes. Besides being used for thatch and basket, a fibre is obtained that can be converted into various kinds of cloth, equal to those manufactured from jute. Thus we have a kind of linen goods made from the cotton plant. Paper is manufactured from the stalk and leaf of the plant.

Cotton hairs are woven into a very great variety of fabrics, more than is imagined by the most of persons; for about two thousand different samples of cotton goods have been reported.

Cotton hairs are readily distinguished under the microscope from any other of the fibres. They are long, several times longer than the

*Isaac Watts, Chairman of the Cotton Supply Association, Manchester, Eng.

diameter of the field—unicellular, flat, but with thickened edges, so that frequently one would say the sides of the fibre were concave rather than flat, always with more or less of a twisted appearance. The fibres of cotton, having only a single layer of cellulose for their cell walls, are easily collapsed. While the cells of linen and of all kinds of fibre consisting of a liber structure are cylindrical or nearly so. When cotton hairs are growing they are full of protoplasm; as soon as they become ripe, however, the protoplasm is absorbed and the thin delicate walls, unable longer to retain their youth and fullness, become wrinkled and collapsed, looking very much like a twisted bit of old ribbon. Any one can see how the cotton hairs look when they are ripe and ready to be gathered, before they have reached the manufacturers' hands, by examining the cotton from our common cotton batting, or by examining the hairs on the surface of the leaf in the white foliage plant called "dusty miller."

Linen comes from the inner part of the bark of the Flax plant *Linum*, and is cellular in structure. There is a central opening running the entire length of the fibre. It sometimes is not possible to see it all the way without treating the fibre with some reagent to bring it out. The cell walls are much thickened by secondary deposits and are tougher than ordinary wood fibre. The firm consistency of the walls keeps the fibres full and round so that linen is never found collapsed like cotton. Occasionally the cells are pointed but generally the ends are square. Sometimes the cells are of nearly the same length as their breadth, though generally much longer. The secondary deposits on the cell wall are quite uneven, so that some cells have a much larger central cavity than others, and occasionally a cell wall will be exceedingly thickened. These layers of cellulose peel off in strips, giving a rough appearance to the surface. When boiled in potasic hydrate or treated with the stronger acids faint spiral markings appear on the cell walls. Jute, flax and hemp are very similar, though coarser than linen.

The individual cells of jute are rather longer than those of linen. Generally of a greyish-brown color, appearing like dead cellulose. Quite a prominent central cavity with smooth edges is present, seeming to be perfectly empty. Much more uniform than in linen. It is apt to break straight across when broken at the ends of the cells, but breaks with a long fibrous fracture if broken anywhere in the middle of the cell.

The fibres of silk are long, slender and rod-like, with occasionally one having a flattened side. When broken the ends separate with a straight or a smooth fracture. They are solid, having very much the appearance of glass rods, no cells, no central opening, no structure whatever. Averaging 1-1600 of an inch in diameter, though some are even 1-800 of an inch in diameter. Their average size is the smallest of the commercial fibres. They have a clear, white color when unstained, and are semi-transparent, and highly refractive.

Wool fibres are either cylindrical or oval. The surface of the fibre is covered by minute cells, lying one upon another like shingles on a roof, or like scales on a fish, though each scale is bordered by a waving line. The value of wool for felting depends on the proportion and size of these epidermal cells or scales. Wool fibres are remarkable for their softness, flexibility and wavyness. These cells are most beautifully seen in white hairs that have been thoroughly soaked in oil of turpentine, and mounted in Canada balsam. Soaking wool fibres in a solution of soda will separate the epidermal cells or scales from the rest of the fibre. Hairs of some animals polarize light. An interesting object of this kind may be made by placing two series of white hairs of a horse in Canada balsam so as to cross each other at an angle and viewing them by polarized light.

The fibres of cotton and linen are not affected by water, alcohol, ether, benzol or any weak solution of the acids or the alkalies, not even when raised to the boiling point. But strong solutions of either acids or alkalies, when applied with gentle heat, will slowly destroy the fibres.

A simple test is the brilliancy of the coloring matter taken by the different fibres, for the aniline dyes give a strong permanent color to silk and wool, while in cotton it is merely surface color and easily washed out.

If you are called upon to examine a piece of dress goods, or any material in which the presence of foreign fibre is suspected, take a small piece of the goods and boil it for a few minutes in a solution of soda (ten parts of soda to ninety parts of water). It dissolves the silk or wool fibres and leaves the cotton or linen unaffected. It is possible to estimate very nearly the proportion of the mixture of the animal and the vegetable fibres, by filtering carefully the residue and comparing with the known amount taken. If the

alkaline filtrate be treated with the acetate of lead the silk will give a white precipitate and the wool a black precipitate.

Wool contains a certain amount of sulphur—silk being entirely free from it. This gives us another means of detection. In a solution of plumbate of soda, wool becomes black while silk is not affected.

NOTE. For illustrations see lithograph plate at end of Part I.

PART III.

SOME HINTS ON THE PREPARATION AND MOUNTING OF MICROSCOPIC OBJECTS.

The following articles, written by W. H. Walmsley, of Philadelphia, are reprinted from "The Microscope."

I.

SO MUCH has been written and published on this well worn subject, that it would seem almost superfluous, if not presumptuous, in me to attempt to add thereto. But recollections of the many failures in my early attempts in years long since gone by, of the wastage of time and materials incurred, and the unsatisfactory knowledge gleaned from books, impel me to jot down for the benefit of others, the results of actual experience in this work.

Whilst by no means asserting that the processes to be described are *the best*, I would say that I have found them to be uniformly satisfactory, yielding always the best desired results, and that all have stood the tests of actual use and experience. I shall give nothing that I do not use in my daily work; and shall not state what "my friend Smith" *says* "is his process," or that "I am told Mr. Jones does this and that." Smith's and Jones' processes *may* be vastly superior to those I shall give, but not having tested, I shall not speak of them, my intention being to give simply and succinctly as possible, my methods of preparing and mounting ordinary objects of interest, which may prove of use to many a beginner in this fascinating pursuit.

Fig. 1. Dissecting Needle.

Nearly all microscopic preparations are mounted in one of three ways: in balsam or other resinous media; in air in the dry way, and in aqueous or other fluids. Of these methods I shall proceed to spesk first of balsam mounts, the *essential* materials for which work are as follows:

A bottle or tube of pure filtered Canada balsam; a bottle each of 95° alcohol, pure benzole, oil of cloves, and liquor potassæ (the latter with glass stopper); a pair of fine *curved* forceps, which should be nickel-plated; another of fine dissecting scissors, and a small dis-

Wheat has been cultivated from the earliest antiquity, and now furnishes the principal bread-stuff of all civilized countries. It is not known to what country it originally belonged; some even have claimed that it was planted upon the earth at the time of the creation. It is certain that it was cultivated in Egypt nearly two thousand years before the Christian Era as we read in the Old Testament, and Chinese history tells us wheat was introduced into China 2,700 B. C. by one of the Chinese emperors. In every country where wheat would grow at all, it has steadily increased in proportion as the country has become civilized and settled. Hostile armies have aided in transporting it from one country to another, and Mexico owes its first introduction of wheat to the brutal conqueror Cortez. It was introduced and cultivated in Peru under the direction of the Spanish lady Maria de Escobar, and the North American Colonies began to cultivate it at the earliest period of their settlement. It was first sown on the Elizabeth Islands, of Massachusetts, by Goshold, at the time he explored the coast, in 1602. It was sown in Virginia, together with other grains, in 1611; however, it was not cultivated to any great extent, because the raising of tobacco was entered into with so much zeal; but in 1651 a premium was given for its culture, when it received a great impetus.

In 1620, wheat, together with rye, barley and other grains, was exported from Manhattan Island to Holland. It was first introduced into the valley of the Mississippi in 1781. The New England states and New York did not raise scarcely any more wheat than necessary for their own use until after the Revolutionary war, but large quantities were exported from New Jersey to Europe, and from Illinois to New Orleans. The price per bushel in 1635 was sixty cents, while in 1860 it was sold for $3.25. At the present time wheat is cultivated over nearly the whole world, being limited only by the rigid cold of the North and the intense heat of the South. We find it exported in large quantities from the United States, Russia, Hungary, Turkey, Denmark and Chili. Next to the United States, it is most extensively cultivated in Russia. The great increase in the Pacific States is worth noticing. In 1850, only 17,200 bushels were raised. Now, we are told, there are many farms of from 2,000 to 4,000 acres, while farms of from 20,000 to 40,000 acres are by no means few, entirely given up to the growth of wheat.

This is due principally to the fact that the summers are long and devoid of heavy rains.

Regarding wheat with a botanical interest, we will find it in the family of *Gramineæ*—the family of grasses—and belonging to the species *Triticum Vulgare*. Of this there are two distinct sub-species, known as Summer and Winter wheat—the Summer, *Triticum æstivum*, and the Winter, *Triticum hybernum*. Each of these sub-species is divided into many varieties, as Treadwell, Diehl, Clawson, Tappahannock, etc. In wheat *Triticum* there is but a single spikelet at each joint; its two glumes placed transversely, and it is from three to several flowered; the lower palet is pointed or furnished at the tips with awn, of variable length; stamens, three. The sub-divisions into Spring and Winter, seem to be the result of cultivation more than anything else, for several different experimenters have been able to produce the Winter variety from the Spring, after several successive trials, and the reverse is also true.

De Condolle—a botanist of high authority—believes wheat to be the result in growth of the cultivation of a wild grass. He even claims that this grass is still growing in certain localities in Central Europe. Many different varieties have been cultivated. One gentleman in France, who has experimented largely with this grain, has succeeded in raising 322 entirely different varieties. The differences between varieties consist in the size of the plant, its shape, habit of growth, in its foliage, in the size or shape of the spike or head, and in the size, form, color and heaviness of the grain. There are about twelve varieties in this country. The same variety is found in different localities under different names, so we have many purely local names. So a certain variety may grow luxuriantly in one locality, and be nearly, if not quite, a failure, in another, due to the soil, climate, and various other causes, singly or combined. But all farmers know that a good soil is as necessary for a good yield of wheat as for any other grain. Of course, pure, clean seed is a most indispensable aid to insure a fine crop, and plenty of skill should be exercised in keeping out all foreign seeds. The weeds which are the most troublesome to wheat are cockle, *hychnie githago*, and chess or cheat, *bromus secalinus*, which is sometimes so abundant that some farmers take it to be degenerate wheat. In New York a great deal of trouble is experienced from the presence of red-root or gromwell, *lithospernum averese*. Then wheat

is troubled with rust, smut, the weevil, the Hessian fly and wheat moth.

Wheat retains its vitality only from three to seven years, and the stories, so generally believed, of wheat being found in Egyptian mummies, thousands of years old, capable of growth, etc., are now discredited. It is believed the cunning Arabs hide these seeds there to deceive the unsuspecting and susceptible traveler, for very recently there have been found Indian corn, and dahlia tubers, exhibited by these sons of the desert as grains and roots which for centuries have been quietly sleeping, waiting only for moisture and sunlight to awaken them to life and growth. 'Tis fortunate for the happiness of our poor Arabs that they are entirely ignorant of the fact that Indian corn and dahlia tubers were not known until after the discovery of America.

Before we take up the minute structure of wheat itself, let us study the microscopic structure of the plant, for every part shows beauties under this aid to the eye, which, without it, would never be mistrusted to exist. Every part of the stem, the root, and head, and seed, would, of itself, form a study, but with limited time and space we can at most only hope to obtain a general idea of the minute structure of each part. Many interesting questions could be answered here, were we not intending only to give the microscopic structure, as: How does wheat grow? How does it assimilate the elements, even minerals, of the soil, transforming material so unlike itself and storing away its starch in the tip of the root at one end and in the center of the kernel at the other? How is moisture gathered from the soil and carried to the extreme end of the head? All these and similar questions are found well explained in our vegetable physiologies, and to these works are our readers referred, while we proceed to give the results of original work, commencing first with the structure of the straw or stem.

If we take a wheat straw that has been soaking in water for twenty-four or thirty-six hours, and with a very sharp razor make a cross section and examine under a microscope, magnifying from 75 to 100 diameters, we will be able to form a very correct idea of the structure of the stem. Only a part of such a section is shown in figure I. This being but a small segment of the circle, which, when completed, forms the entire circumference of the straw. The whole structure is made up of vegetable cells, only many are modi-

fied differently in order to fulfill some special object, for which they were made.

The principal framework of the straw is built up of such cells as appear at *D*, very thin walled and hexagonal. These cells are modified in shape as they approach both the inner and outer edge of the figure. At the inner edge we see regular four-sided, thin-walled cells; as they reach the outer edge we find the walls quite thick and the cells also four-sided. The row of cells as seen at *C*, form the epidermis of the straw, and is composed of a simple layer. The outer edge of these cells is quite thick-walled, and forms the cuticle. This cuticle is what gives the smooth polish to the surface

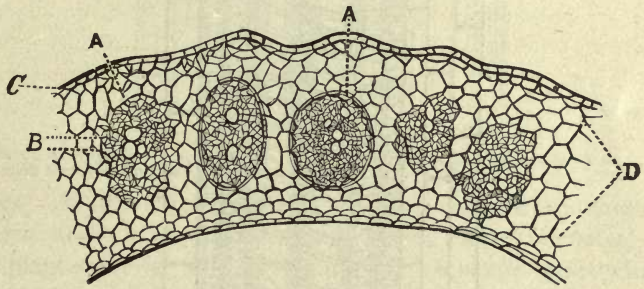


FIG 1. CROSS SECTION OF WHEAT STRAW.

A, Vascular Bundles. B, Spiral Vessels. Drawn with Camera Lucida, X 75.

of the straw. In some varieties of wheat this cuticle is much thicker than in others. If the season is a long, cold, stormy one, or if the wheat grows in a cold climate, the cuticle will be found to be thicker and more leathery. The darker round portions of the figure, as seen at *A*, are the woody portions of the straw, or, as they are called, fibro-vascular bundles. The fine cells forming the most of these bundles, are woody cells, while the large openings near the center of these bundles are the cross sections of large vessels or ducts that run the whole length of the straw.

Figure 2 represents a longitudinal section of a vascular bundle. The cells shown on either side of this bundle, at *C*, are the fundamental cells seen in cross section at *D*, Fig. 1. The cells at *B* are the woody portions seen at *A*, in Fig. 1. They have very peculiar little pitts covering their surface. The large vessels at *A*, Fig. 2,

are the same as those seen in the cross section at *B*, Fig. 1, only magnified many times more.

The spiral bands arranged so beautifully around these vessels are little fine tubes, coiled around on the inside of the large vessels, and growing firmly to the inside wall. Water or moisture is carried the length of the straw by this spiral tube, as well as being absorbed through the cell walls.

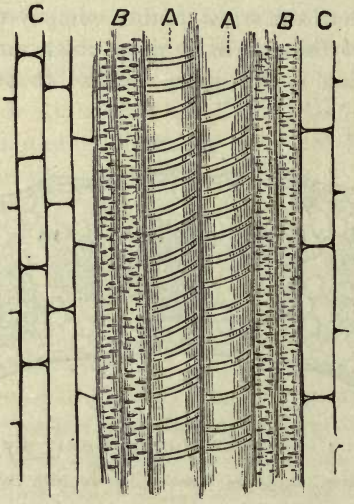


FIG. 2. LONGITUDINAL SECTION OF WHEAT STRAW.

Showing a Vascular Bundle. A, Spiral Vessels. B, Pitted Vessels. C, Regular Parenchymatous Cells. Drawn with Camera Lucida, X 375.

The only object of the woody portion of the straw is to give strength enough to the plant to hold up its head until the wheat is ready for the harvest. The spiral vessels and woody portions do not, as many suppose, carry *all* the sap through the plant. The sap is carried right through the cell walls by absorption, principally by those cells found at *C*, Fig. 2, and at *D*, Fig. 1. In order for the sap to be raised one inch, it is obliged to pass through over two thousand of these cells.

Fig. 3 shows the epidermis covering the outer surface of the straw. It has been torn off lengthways, and is the single layer of cells seen at *C*, Fig. 1. The long, narrow cells at *B* make up the

epidermis as it covers the vascular bundles or ridges found running lengthways of the straw. The larger cells, at *C*, are found covering the grooves seen in the depressions in Fig. 1 between the vascular

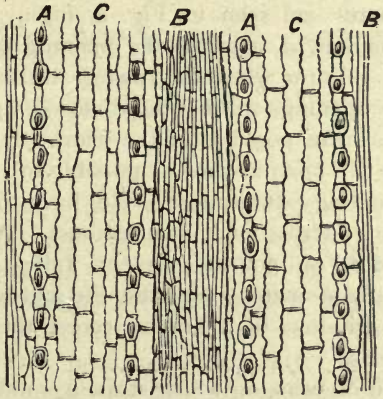


FIG. 3. EPIDERMIS OF WHEAT STRAW.

A, Rows of Stomates. B, Opposite, or over the Vascular Bundles seen at A, Fig. 1. Drawn with Camera Lucida, X 75.

bundles. At *A*, we find peculiarly modified cells surrounding openings that are the regular breathing places, called stomates. The wheat plant must be able to breathe, to exchange gases with the

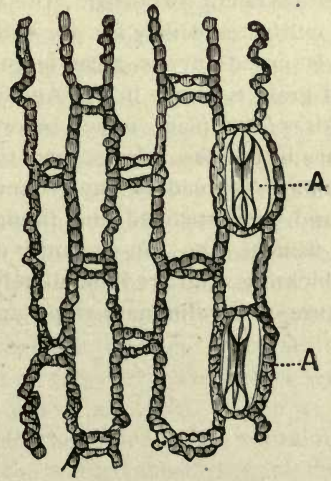


FIG. 4. EPIDERMIS OF WHEAT STRAW.

Same as Fig. 3, magnified more. A, Stomates or Breathing Places. Drawn with Camera Lucida, X 375.

surrounding air, to throw off a superfluous amount of moisture, or to absorb moisture from the atmosphere when the earth is too dry to supply its demands.

These stomates are seen in Fig. 4, highly magnified. The dark line at the center, *A*, is where the opening occurs, here represented as closed. As the wheat is growing in the field if a dry, hot day comes, these openings will be found closed tightly, in order to retain all the moisture possible in the plant. If the day is damp, the little mouths will open as wide as possible to exchange moisture with the surrounding atmosphere. We have proved this many times by careful microscopic examinations. Where this power of moving resides is not at present fully determined, but true it is these little stomates guard the life and habits of this plant as closely as the windows of a house protect the inside from the storm.

The question of utilizing wheat straw has not been acted upon to any great extent by our American farmers. In some countries it is considered of great commercial value. In Ecuador the most of the native women and children are employed in picking and sorting straws for market. Large quantities are imported to America to be made up into straw work, but the most of it is made up into hats and fancy work before being exported. In Tuscany a peculiar variety of wheat is cultivated, solely for its straw, known as *Triticum tungidum.* It is noted for its great length, slenderness and strength. The seed grain is grown in the Apennines and the straw crop on the low lands. The plant is cut before maturity and left on the ground to dry in the sun. It is then tied in bundles and stalked. It is afterwards spread on the ground to be bleached by the sun and dew, and then steamed and fumigated with sulphur. They are sorted by women, who can instantly detect the slightest difference in their thickness, and are immediately plated, for, owing to their flexible nature, no preliminary steps are necessary to this process.

THE MICROSCOPICAL STRUCTURE

OF THE DIFFERENT COATS.

WOULD you believe there was any great complexity in the structure of a grain of wheat in looking at it with the naked eye?—for certainly it looks like the most simple thing in the world. Yet that very little grain possesses a mechanism even more complicated and curious than the structure of the most elaborate machinery. It would be impossible to produce it artificially. No mechanical work would be able to produce the delicate tracings or the minute cell divisions which the microscope shows to be so beautiful. Neither could it produce the nearly transparent covering, so delicate, so thin, and yet so strong and tough, as to bravely withstand the effects of moisture. That the wheat is minute as well as intricate in its structure, we shall see before we are through with this study.

A grain of wheat is oval or egg-shaped, with a deep longitudinal furrow on the inner face; with a keel or irregularly curved surface covering the embryo on the back near the base of the grain, and with quite a heavy growth of vegetable hairs at the opposite end or the apex. It must be remembered that a grain of wheat is not a seed as so many think, but rather a perfect fruit enclosing the seed within itself, so necessarily its structure is more complex. Starting from the outside of the kernel, let us see what different structures we find before reaching the center. First, there are three fruit coats known as the first, second and third fruit-coats, then there are two seed-coats known as the first and second seed-coats. This makes five distinct coats surrounding a grain of wheat, which, taken all together, have a thickness of less that 1–15 of a millimeter (1–400 of an inch). Then we come to a coat as thick or thicker than these five coats, containing the nitrogenous substances. Then the whole central mass of the grain loaded with starch, and last the embryo at the base. It may make this clearer if the different parts are tabulated as follows:

FRUIT-COATS OR PERICARP.	1. Outer fruit-coat, or epidermis, or EXOCARP. 2. Middle fruit-coat, or MESOCARP. 3. Inner fruit-coat, or ENDOCARP. 4. Vascular bundle.
SEED-COATS.	5. Outer seed-coat, or TESTA. 6. Inner seed-coat, or ENDOPLEURA.
ALBUMEN.	7. A single layer of large cells filled with gluten and nitrogenous products—PERISPERM. 8. Large hexagonal cells filling the central part of the grain and loaded with starch, etc.—ENDOSPERM.
EMBRYO.	9. A single layer of empty compressed cells. 10. Regular hexagonal cells of the embryo filled with starch, oil, etc.

As we understand the term "bran," it includes the first seven of these parts, that is, all of the different coats of the wheat.

1. The outer fruit-coat, or the epidermis, consists of a single layer of cells—see Fig. 1.—similar in appearance to those found in the epidermis of the straw,—long, narrow cells with a strong cell-wall, looking something like a string of beads. An important thing to remember is that the longest way of the cells is with the length of the grain. About the center, that is, midway between the two ends on the surface, these cells are in length nearly three times the width, while as they approach either end they gradually grow shorter and rounder. Occasionally stomates are found in the epidermis, but not regularly as in the straw. At the apex of the grain,

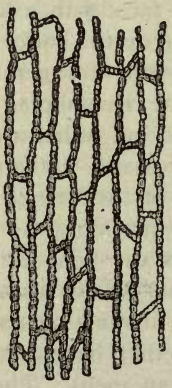


Fig. 1. Epidermis or First Fruit-coat of Wheat. X 75.

and growing out from this layer of cells, are the long slender hairs seen in Fig. 2; "A" shows the epidermis and the way the hairs are embedded in the cells. These hairs are composed of a single cell

with very thin cell-walls which leave quite a cavity in the center as seen at "B." This cavity in all probability is filled with gas of some kind, and if we estimate several hundred of these hairs on each grain of wheat, which is by no means too large an estimate, would it not be right to wonder if the breaking up of these hairs and the escaping of the gas might not be sufficient to explain some of the mill explosions of the present time? With this thought in mind we obtained a short time since some of the dressings left after the flour had passed through a middlings purifier, and were surprised to find such a large per cent. of the mass to consist of these

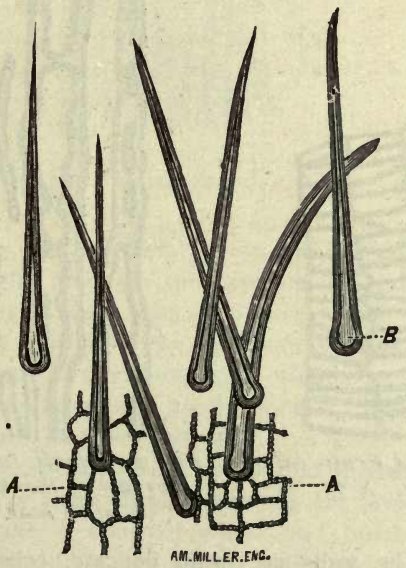


Fig. 2. Hairs found at the end of a Wheat Kernel. X 75.

hairs. Nearly half of the entire quantity was composed of these fine, delicate hairs, that are so light and inflammable. Chemistry teaches us that almost any dry material when powdered and mixed with air in just the right proportion, will explode if a flame is brought near. Now these hairs are so light and dry that they float in the air easily, and they burn very readily when thrown into the air over a gas-jet. If chance has mixed this dry powder at just the right proportion with air for an explosion, and if chance has

brought a lighted lantern or a flame of any kind in contact with the mixture, who can say what would be the result?

Certainly the subject is well worth experimenting with, and the miller is in a much better position to do this than the scientist, for he is acquainted with all the practical workings of the mill, and familiar with all the questions of mill explosions.

2. The middle fruit-coat, or *mesocarp* as called by botanists—is made up of several layers of longitudinally extended cells, similar in appearance to the first coat, only not beaded

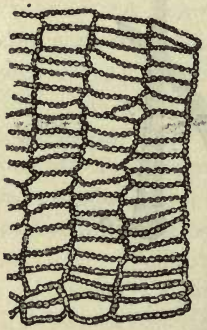


Fig. 3. Third Fruit-coat of Wheat. X 75.

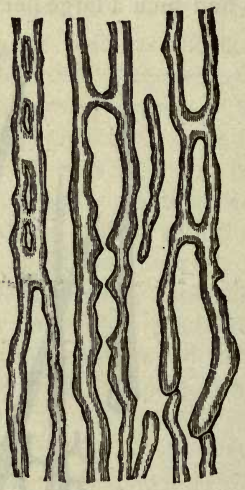


Fig. 4. Canals found on the inner surface of the third fruit-coat of Wheat. X 375.

so strongly. The walls are more delicate, cells a trifle wider and closely adherent to each other and to the epidermis. It is almost impossible to separate these two coats without the aid of re-agents.

3. The inner fruit-coat or *endocarp* is composed of long, narrow cells similar to those of the first coat, only lying at right angles to them, that is, the longest way of the cells lies cross-ways of the grain. (See Fig. 3.) They are from 1-150 to 1-300 of an inch in length. The walls are more finely beaded, presenting a stronger appearance than in the outer fruit-coat. It is almost impossible to mistake any of these coats

under a microscope, or even to get them confused, for they are generally together, and are always the same, whether you find them in flour, in studying the structure of the grain, or, as is too often the case, when we find them where wheat has been used as an adulteration of some ground spice or drug.

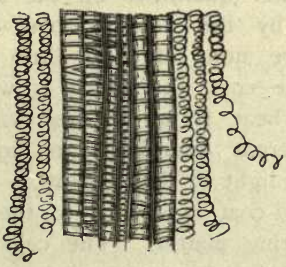


Fig. 5. Spiral Vessels found in Wheat. X 400.

The three coats lie together, but in one direction we see only one layer of cells, while in the opposite we find three or more. The single layer is the third fruit-coat, while the others are the second and first. On the underside of this fruit-coat, and attached firmly to it, are found very peculiar canals, frequently anastomosing, and having thick walls. They run lengthwise of the grain, and in this way give great strength to the fruit-coats. (See Fig. 4.) What remarkable provisions for strength we see in the way these three fruit-coats are arranged.

4. If you take a grain of wheat and break it open longitudinally, breaking it in the crease made by the deep groove, and examine the edges of the epidermis as they fold over in this groove, you will find a line of a deeper color than the rest of the wheat grain. If this dark line be taken out and treated with potassic hydrate and examined under the microacope, s delicate vascular bundle will be seen. (See Fig. 5.) Another sign of strength in the grain. The spiral vessels are seen plainly as they uncoil under the action of the re-agent, as shown on either side of the figure. This vascular bundle is seen plainer near the center of the grain than at either end.

5. We have divested our grain of its fruit-coats, and have

now nothing except the seed left. There are two seed-coats, made up of long, slender cells, with very thin, nearly transparent cell walls, the cells of two coats cross each other at right angles. The outer seed-coat or *testa* is the coat which furnishes the coloring matter, and decides whether the grain shall be red, yellow, or white. The coloring matter exists in little roundish masses, seen in greater quantities on the surface of the grain which is protected by the deep groove, or near a vascular bundle. If there are none of these little masses of coloring matter present in the coat, the wheat is white, if there is a great quantity the wheat is of the red variety; and between these come the different quantities, and in proportion to the amount, the wheat is light or dark yellow.

6. The second seed-coat is similar to the first, only wanting the pigment or coloring matter. The cells of both coats are collapsed and hard to demonstrate, and not of sufficient importance to illustrate.

Thinking some of our readers might like to make some of these examinations themselves, we give some of the details of the work.

Let the grains soak in warm water for about twelve hours, then hold a grain on the end of a needle which has been wedged into a wooden handle, and with another needle pick off carefully the outer fruit-coat and examine with a microscope. It is so coarse as to be seen readily with a magnifying power of fifty diameters. After this it should be examined with a higher magnifying power in order to see the beaded structure. After removing carefully the epidermis place the grains back in the water and allow them to soak from twelve to twenty-four hours longer. The second and third fruit-coats can now be examined. If these are picked off carefully and the grain allowed to soak a few hours longer, the remaining structures can be separated and examined.

THE COATING AND CELLULAR STRUCTURE

OF THE WHEAT BERRY.

7. WE have disposed now of the woody part of the grain, and have just reached the layer of cells, which is possibly of the most interest to millers. A layer of large, nearly square cells, with very thick walls and filled with fine granular matter, see Fig. 1. The cells are 1-20 of a millimeter (1-500 of an inch) in diameter, and quite uniform in size. The cell walls are composed of several layers of cellulose, presenting somewhat a laminated appearance under the microscope. These layers can be separated from each other quite distinctly by boiling in water for several hours or in a solution of caustic potash for a short time. The granular contents are enclosed in sacks, which are embedded in the cellular walls, as seen in Fig. 3, where the two sacks have floated out of their usual resting place. These sacks contain nitrogenous substances, and contain them in much larger proportions than any other part of the grain. If any means could be employed by which the grain could be divested of all its coats excepting this last, and this last coat could be treated in such a way as to separate the nitrogenous sacks from the framework holding them, and then have the sacks form a part of the flour, we would probably have the finest and purest flour possible. The process of scientific milling has made such great advance during the past twenty-five years, who can say but ere the next twenty-five years pass, we shall have these microscopical sacks of nutrition separated out from the woody part of the grain. The gluten, or nitrogenous substances, exist in very minute particles, about 1–600 of a millimeter (1–15000 of an inch) in diameter. They are insoluble in water, alcohol and glycerine, and are not affected by iodine or potassa. Ammonio-nitrate of silver turns them a dull yellow, while a solution of carmine turns them a

bright yellow. Nitrogen is found only in cell-contents, and is never found in cell-walls.

8. Inside of the layer of albumen is found only one structure until we reach the embryo, at the base of the grain. It is composed of large, thin-walled hexagonal cells, loaded with starch, see Fig. 2. To see these cells plainly under the microscope a very thin section must be cut from the central part of the grain with a razor, or a sharp knife, and then washed off carefully with a camels-hair brush, so as to remove the

Fig. 1. Outer Layer of Albumen. X 200.

grains of starch, when we find a delicate white structure resembling a honey-comb in all except color. At the center of the grain the cells are the largest, and are quite uniform in shape and size, measuring nearly 1–10 of a millimeter (1-250 of an inch) in diameter. At the surface of the albumen the cells are quite long and narrow, and lying in such a way that they appear to radiate from the center toward the surface. The walls are delicate and nearly transparent, showing under a high magnifying power the different structures or layers of cellulose. The cells are loaded with starch grains, as seen at *a*, Fig. 2.

9. Just inside the hexagonal cells, which fill the inside of the grain, and at the same time surrounding the embryo, is found a single row of empty compressed cells, quite difficult to demonstrate.

10. The embryo occupies the lower end of the grain, and is a small oval body about one millimeter in width and two in length. The main object in life for the wheat is the production of this embryo. The development of the stem, the branching and expanding of the leaves, the whole life and his-

tory of the blossoms, is for the development of the life-germ contained within the embryo, and when this is produced the whole plant dies. The hard coats we have already described are made only to protect the starch and albumen of the center, and to give warmth to the embryo, while the starch and albumen, which are stored away in such profusion in the grain, are only formed to give nourishment to the germ while it

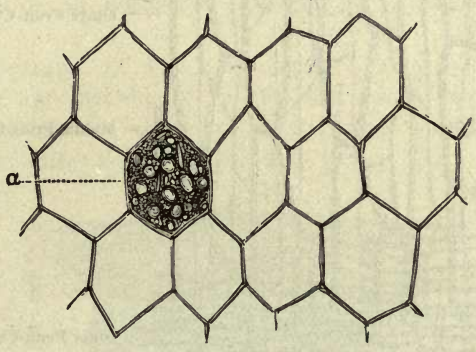


Fig. 2. Hexagonal Cells from the Central Part of a Grain of Wheat. a, shows a Cell filled with Starch Grains. X 100.

grows. The structure of the embryo will form a study by itself, as it is very complicated, containing within itself all the parts of the new plant, which it will produce when placed under favorable circumstances.

Fig. 3 gives a diagramatic view of the "bran" of wheat, or of all the different coats, and of the outer layer of cells containing the albumen and gluten. Any of my readers who have examined the wheat with the microscope know how difficult it is to separate the first and second fruit-coats. They almost always are seen together, as in the figure, while very generally the round cells of the albumen are seen together with the different fruit-coats, particularly with the inner fruit-coat. When the outer fruit-coat is examined with the microscope, and is in focus, the middle coat is not seen distinctly; occasionally is caught a glimpse of the beaded structure. Very frequently the three fruit-coats are together, as in the figure. Just beneath the third fruit-coat are seen the canals. The two seed-coats seen just below the canals, and at the lower right-hand corner of the

figure, show as distinctly as they are generally seen. Frequently there is no appearance of cell structure in either of these coats. Immediately below the two seed-coats is found the outer layer of albumen, seen at the lower left-hand corner of the figure. By the openings around the edge of the layer, we see that the

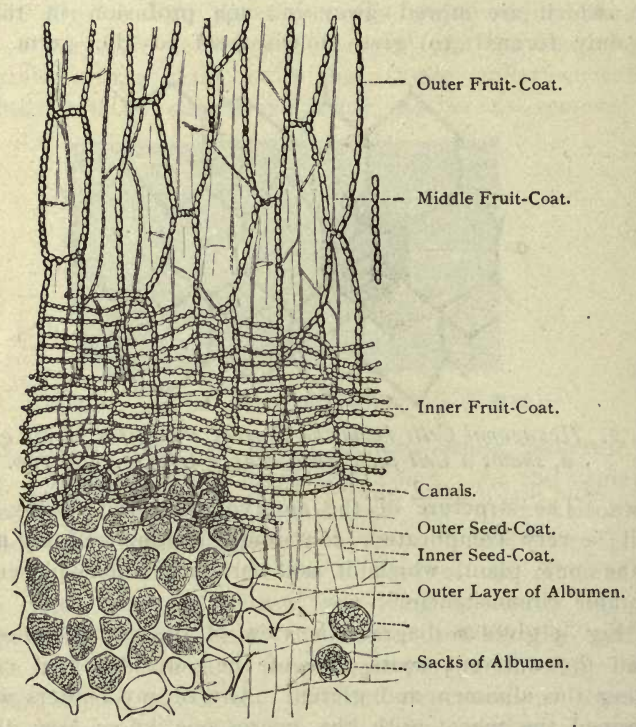


Fig. 3. Showing the Different Coats of Wheat.

granular matter is contained in sacks. Two of the sacks have floated out and are seen as distinct from the coat.

In Fig. 4 we have a cross section of a grain of wheat, shaved off nearly midway between the ends. At *A*, is seen a thickening of the outer fruit-coat, which is given for extra protection to the grain. At *B.* are seen the openings formed by the cells of the first fruit-coat. They are much larger in some varieties than the cells of the second fruit-coat, as seen at *C.* The peculiar beaded structure of the third fruit-coat is

seen at *D*. It must be remembered these cells run around the grain, while in the first and second coats the cells run lengthwise. At *E*, are seen the two seed-coats. Here again there is a slight thickening of the outer cell-walls. The masses of coloring matter are located in the outer layer of *E*, and are seen as little dark crystals. At *F*, is seen the outer layer of albumen, quite large cells, arranged perpendicular to the surface. Inside of all come the regular cells of the center, filled with starch.

The appearance of the starch under the microscope is very characteristic and peculiar. Pure wheat starch can be obtained by cutting through a grain of wheat and scraping with the point of the knife a little from the central part of the grain

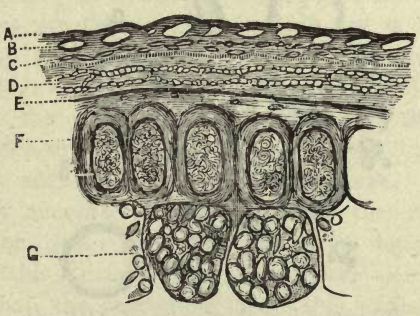


Fig. 4. Cross Section of Wheat. Drawn with Camera Lucida. X 200.

on a glass slide. By placing a drop of water on the specimen and examining it then with a microscope we are prepared to study its appearance. There are two distinct kinds of starch grains floating in the field; small, spherical or angular starch grains collecting frequently in masses, many times more numerous than the large grains, about 1–200 of a millimeter, (1–5000 of an inch) in diameter. The others are large lenticular grains, which when viewed on the face, appear like a spherical body, but when viewed on the edge, appear like a double-convex lens, see Fig. 5. This lens shape can easily be proved by touching the cover-glass gently while under the microscope, with a pencil point, and watching the grains roll over in the field, presenting alternately the appearance of a sphere and a lens. This simple test should always be used when

working out the adulterations of any flour or spice. There is seldom any nucleus present; when it is present though, it will be found near the center of the starch grain. Still more seldom are there any rings present. According to Dr. Julius Wiesner, Professor in the University of Vienna, there is to be found still a third kind of starch grains in wheat; a compound grain found in the interior of the outer layer of albumen, and made up of from two to twenty-five individual granules. These compound grains are very seldom found in either the flour or in commercial wheat starch. Occasionally broken pieces of the compound grains are found, but these are about all the indications of a compound grain we see. They are ellip-

Fig. 5. Starch from a Grain of Wheat. X 375.

tical or egg-shaped and frequently much larger than the lenticular grains. When subjected to dry heat, the grains of wheat starch are changed very much in appearance, being warped considerably from their normal shape. They are larger, more brittle and more transparent. However, they generally can be identified, when subjected to either dry or moist heat—if the moist heat be not raised to boiling-point, which would change it to a gelatinous mass. The large grains of wheat starch in their natural or normal state are very uniform in size for the same variey of wheat, but the starch grains found in the different varieties of wheat differ considerably in size. The average size is about 1–40 of a millimeter (1–1000 of an inch) in diameter. The theory of the growth and formation of these starches is of considerable interest.

Starch is the most generally diffused, excepting protoplasm, of all vegetable substance within the cell-wall. When found in the older structures, roots, stems, seeds, etc., it is found nearly pure; when found in freshly growing tissue it is in union with chlorophyll. Starch grains contain carbon, oxygen, hydrogen, and some mineral matter. They are insoluble in water, alcohol, ether and oil, are destroyed by potassa, and colored blue or violet by iodine, the color depending on the density of the granule and the strength of the iodine. The starch grains of different families and different species of the same family differ so much in size and general appearance as to be easily identified. The largest starch grains known are those of the *tous-les-mois* which are frequently 1–12 of a millimeter (1–300 of an inch) in diameter, while the smallest of the commercial starches are those of rice, which are occasionally 1–280 of a millimeter (1–7000 of an inch) in diameter. There are two leading theories regarding their growth. Some claim that the surface of the grain is first formed, and that it grows by layers, being deposited on the inside of the case, which gradually expands until it reaches its normal size. The other and more generally accepted opinion is, that the nucleus is first formed, and the grain grows by means of deposits of starchy matter around this nucleus, and each successive layer contains less moisture than the preceding layer; this explains the appearance of rings or laminæ seen occasionally in the wheat starch, but showing so plainly in the potato starch and many others. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain, and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. In very many starches there is a distinct dark cross seen when viewed with polarized light, the arms of the cross radiating from the nucleus. Some botanists claim that a cross can be seen in wheat starch, but if this be true, it is different for the starch of the different varieties of wheat. In some grains of wheat starch there is no appearance of a cross, while in some others there is a faint shadow crossing the grain while polarized light is being used.

VARIETIES OF WHEAT.

THE peculiarities of a vegetable growth are transmitted from one generation to another; that is, plant characters are hereditary. There are certain characteristics of every species which are produced in generation after generation of the plant, while frequently peculiarities will be possessed by an offspring which were not found in the parent plant. Occasionally these distinctive peculiarities or characters will belong only to the individual plant, while in other cases they will be produced in their descendants, and become hereditary. When a new property or character is transmitted by inheritance to new generations, so as even frequently to become as constant as the primative form, we have what is known as a new variety. *Varieties* are constant forms of new characteristics.

There is a great difference in plants in their tendency to produce varieties. Some plants seem to have no disposition to variation, but are distinguished by the consistency of their characters, as, for example, rye, which has as yet produced no hereditary variety, notwithstanding long cultivation, while, on the other hand, some plants seem to have the greatest proclivity for change. The same parent plant may produce numerous varieties; as, for instance, our common garden dahlia, with its hundreds of different forms, have all come from the simple yellow blossom, which was cultivated for the first time in 1802. And the almost innumerable varieties of pansies, distinguished chiefly by the color of their flowers, are all cultivated from the common, wild violet, while almost as numerous are the varieties produced from our common field pumpkin—*Cucurbita pepo*—from which have been produced all the varieties of water melons, gourds, musk-melons, squashes, cucumbers, etc. The character of many of these varieties seems to

be perfectly hereditary, and all the organs show the greatest degree of variation. The fruit of one variety is more than 2,000 times the size of the fruit of another variety. The varieties of melon differ very much, some being as small as plums, while others weigh as much as 66 pounds; one variety has a scarlet fruit; another is only an inch in diameter, but is three feet long, and is coiled in a serpentine manner in all directions; the fruit of one variety can scarcely be distinguished externally from cucumbers; one Algerian variety suddenly splits up into sections when ripe. The cultivated varieties of corn are descended from a single primitive wild form, which has been cultivated in America for a long period. There is at present a very wide difference between the cultivated varieties and the primitive one, as well as a very great difference between the cultivated varieties. Some of the plants are only one and one-half feet high, while others are from fifteen to eighteen feet. The grains vary extremely in form, size and number, while in color they vary from white, yellow, red, orange, violet, streaked with black, blue, or copper-red. There is even one variety of corn which has three different

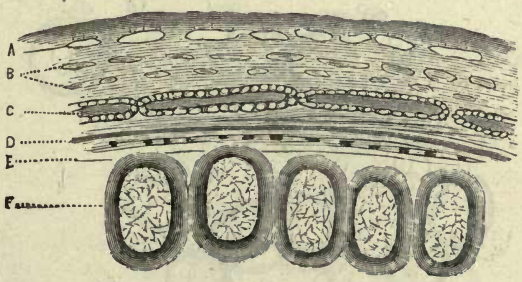


Fig. 1. Cross Section of Diehl Wheat. X 250.

A, First Fruit Coat; B, Second Fruit Coat; C, Third Fruit Coat; D, First Seed Coat; E, Second Seed Coat; F, Albuminous Layer. Drawn with the Camera Lucida.

kinds of fruit, differing in form, color and size, on one ear. These illustrations are used only to show to what extent the amount of deviation in the varieties of a primative form may increase under cultivation. Wheat gives us just as fine an illustration of the great variation in a vegetable form as any of those already mentioned. The three different spec

of wheat known as *Triticum vulgare*, *Amyleum*, and *Spelta* seem to be the most prolific in producing varieties, for from these three seem to spring an ever increasing number. The char-

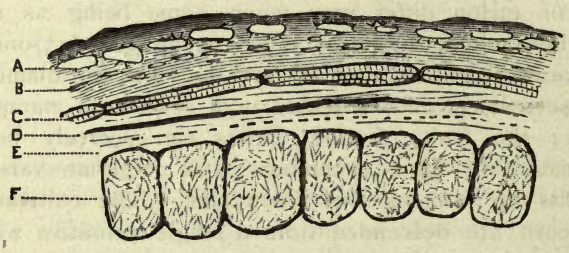


Fig. 2. Cross Section of Clawson Wheat. X 250.

A, First Fruit Coat; B, Second Fruit Coat; C, Third Fruit Coat; D, First Seed Coat; E, Second Seed Coat; F, Albuminous Layer. Drawn with the Camera Lucida.

acters of the cultivated varieties of one parent-plant shows, according to Darwin, a constant, striking and remarkable relation to the purpose for which the plant was cultivated by man. The varieties of wheat differ from each other only slightly in the size of the stalk, or in the form of the leaf,

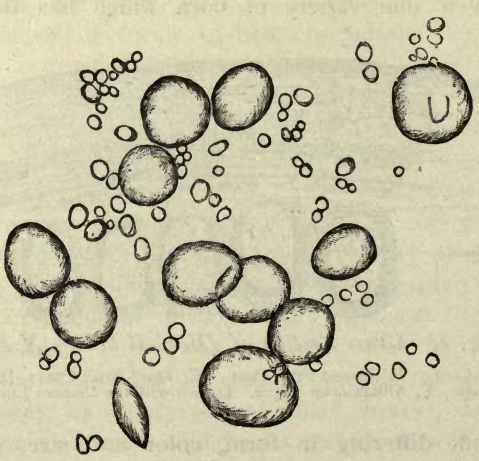


Fig. 3. Starch Grains of Diehl Wheat, or Diehl Flour. Drawn with Camera Lucida. X 475.

which are of little importance to mankind; but they show a great variety and extent of difference in the form and size of

the grains, and in the amount of starch and proteine contained in them. In other words, the greatest characteristics are found in those parts of the plant for the sake of which it is cultivated and in those properties of these parts which, under various circumstances, are especially useful to mankind.

The causes producing variation in the vegetable forms are yet under discussion by botanists, although some of them are settled beyond a doubt. One general occasion for the appearance of new individuals, differing from the old stock, is the fertilization of the known species, by the pollen-grains of some strange variety. These pollen-grains may come from some wild specimen growing in the adjoining woods, or even from the wheat-fields of some neighboring State. The wheat-fields need not lie adjoining each other in order that the one may fertilize the other, for the pollen-grains are so very minute the wind might carry millions of them immediately in front of our

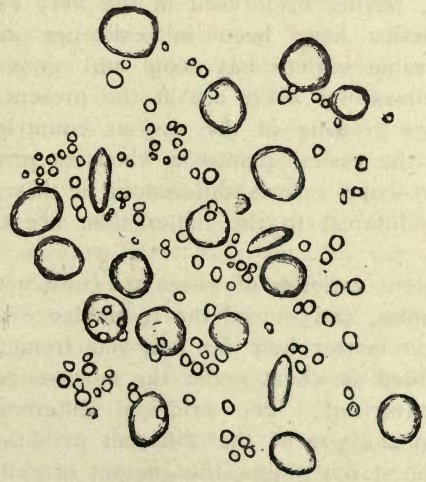


Fig. 4. Starch Grains of Clawson Wheat, or Clawson Flour. Drawn with the Camera Lucida. X 475.

eyes, yet we could not see that the air was darkened in the least by their presence. They are so light they can easily be carried miles by the air before they are dropped. Sometimes it happens that a single bud or blossom, for some unaccountable reason, will develop differently from all the other buds

of the plant. This single individual would, in several years, produce quite a growth. Then there are changes produced in a plant by the nature of its food and other external conditions. Specimens of the same kind will differ very conspicuously in the size and number of their leaves, flowers and fruits, according as their supply of food has been abundant or deficient. Deep shade frequently produces the most striking change in the habits of wheat when they are accustomed to grow in the sunlight, as all farmers can testify. These practical questions are studied carefully by farmers whenever they wish to produce any particular variety of wheat.

Unfortunately, it is not known to what country we are indebted for the primitive plant of wheat. One of the greatest botanists (De Candolle) claims that the original grass from which wheat has been produced is yet growing in some obscure locality in Central Europe. However, it is the oldest cereal known, having been used in the very earliest time. So probably varieties have been in existence and disappeared. Perhaps the same variety has come and gone on the world's stage many times, for there are at the present time many different varieties growing in the various countries of the world. It is one of the easiest plants in which to produce variations.

The microscope reveals differences in these varieties, which are of more interest to the miller than are the physical appearances.

The different varieties of wheat are constructed on the same general principles, and indeed the resemblance is so strong that any variety, no matter how far removed from the typical form, can be identified as wheat under the microscope, however finely it may be pulverized. The principal difference between the varieties is in the size of the different parts; as, for example, the size of the starch grains, the amount of cellulose packed on the cell-walls, or the thickness of the different coats. The examination and the measurements for this work have been made with considerable care, while the illustrations are all drawn with the camera lucida, so there can be no chance for the author's imagination to play any part in the drawings. (A camera lucida is an instrument which, by means of a prism or glass set at a certain angle, the image of the object in the microscope may

be thrown on the drawing-paper, and there traced accurately with the pencil.) The following are the varieties which have been examined: Diehl, Treadwell, Tappahannock, Wicks, Egyptian, Schaffer, Russian and Clawson. The largest and coarsest structure of all was found in the Diehl wheat, although the Treadwell was so nearly the same that it would be almost impossible to separate them, while the smallest measurements were found in the Clawson. All of the other varieties fell between these two extremes, and in about the order named. Figures 1 and 2 give cross sections of Diehl and Clawson wheat. These sections were cut from as near the center of the grain as possible. At *a*, *b* and *c* are seen the fruit-coats; but see what a difference there is between the two specimens. The fruit-coats of Diehl are so coarse and thick, as compared with the corresponding ones of Clawson wheat. The same difference can be seen in the two seed-coats *d* and *e*, while the greatest difference of all seems to be in the immense, great walls of the cells constituting the albuminous layer. There appears to be no deficiency in the growth of cellulose, when Diehl or Treadwell wheat are cultivated. This cellulose is what composes the great mass of woody structure, and is just as easily digested as wood. This albuminous layer furnishes the largest proportion of nitrogenous substances. Any one can readily see that the thicker the cell-wall for the same width cells, the less nutrition there will be. So the amount of nitrogenous substances contained within the cell-walls of Diehl wheat is not as great in proportion to the size of the whole cell as the amount contained in the corresponding cells of Clawson. All of the structure which appears in these cross sections properly belong to the bran, and hardly form a part of flour. If it were possible to secure all the nitrogenous substances out of their native layer, *f*, allowing them to be a part of the flour, and discard the rest of the structure belonging to the different coats, you would have the most nutritious and the very best quality of flour.

The flour produced from these varieties of wheat is probably of greater interest to millers than the bran. In the case of the flour, as well as the structure, Diehl and Clawson are the two extremes, while the other kinds are found somewhere

between them. See Figures 8 and 9. The greatest difference is found in the size of the large grains of starch, those of Diehl being $\frac{1}{816}$ of an inch in diameter, while in Clawson they are only $\frac{1}{1256}$ of an inch in diameter; Treadwell, $\frac{1}{860}$; Wicks $\frac{1}{881}$; Egyptian, $\frac{1}{994}$; Scaffer, $\frac{1}{1000}$; Russian, $\frac{1}{1174}$. Although the difference is nowhere near as marked in the small grains, still there is considerable difference in their size. Schaffer, $\frac{1}{4700}$ of an inch in diameter; Treadwell, $\frac{1}{6100}$; Russian, $\frac{1}{4000}$; Egyptian, $\frac{1}{6000}$. These measurements were obtained by taking a large number of as nearly typical grains as possible, measuring them accurately, and then obtaining their average diameters.

Adulterations of Wheat Flour.

It is not the aim of these articles to give information that will enable a miller to sell, at first class prices, a quality of flour that ought never to be sold; nor is it to show how dark, musty flour may be rendered so white as to deceive the public; nor to prove how wicked it is to sell substances unwholesome or injurious to health under the name of wheat flour. But the aim is to show how easily any foreign substance in flour may be detected. The miller who prides himself on the secrecy with which he, in the dark recesses of his mill, grinds up different substances to mix with wheat, little dreams that it is impossible for him to powder them so fine that they cannot be seen under a microscope. There is nothing used to any great extent, either as a substitute or an adulteration of wheat flour, that has not been detected by either the microscopist or the chemist. And any miller, with a slight expense to himself of time and money, may learn to detect foreign substances, if present, in any specimen of wheat flour that comes to his notice. A microscope, some published illustrations of the different ingredients that one meets, together with a few weeks of practice, will be all that he needs. There are a few chemical substances whose presence can not be detected by means of the microscope. Chemical tests have to be called into requisition to discover these. Mineral ingredients have been reported many times, by foreign writers, as forming a part of flour, but these substances have never been reported, to my knowledge, as an adulteration used by any American miller. Their detection will be spoken of in the proper place. We have to deal now only with the simple forms that are found so readily with the microscope.

As these articles are to instruct, and not to please, I will digress long enough to say a word about the choice of the microscope necessary for such work. Any cheap, simple stand

—and there are so many in market, it will not be necessary to give the name of any particular maker—a ¼-inch objective, with a "C" eye-piece, that will give a magnifying power of from 350 to 500 diameters, will be needed. The whole may be obtained for $25, or possibly less. As a rule for simple work in microscopy, a stand with the least mechanism and the fewest adjustments is the one which can be worked with the most satisfaction. It would be very advisable to have a low power for work some of the time, either a 1-inch or a ½-inch objective. Unfortunately for those who attempt to accomplish this work by themselves, there are very few published illustrations on the subject which will help them. Many articles have been written, telling what is occasionally seen in wheat flour that does not belong there, and how it is to be found, but they give the reader little idea of how the substance looks or how it is to be identified. The surest means of identification is by close comparison with published illustrations, that have the merit of being somewhat accurate. In selecting a microscope, one should be obtained having such a combination of objective and eye-piece as will magnify the same as does the microscope from which the illustrations were made that you use for your guide. If, for instance, your microscope magnifies 800 diameters, and the illustration with which you compare your specimen was magnified only 100 diameters, you would see little resemblance between the two.

Flour is subject to adulterations of two kinds, which consist in the addition of mineral or of vegetable substances, and there seems to be two objects to accomplish by this addition. By mixing materials of a cheaper or poorer quality, the weight and bulk of the flour will be increased, or, by adding some ingredient to flour of an inferior quality, it is rendered white enough to pass for the best quality.

The following list of adulterations is given by different authors as having been found in wheat flour: Those used to increase bulk or weight are; corn, potatoes, beans, peas, oats, barley, buckwheat, rice, clay, bone-dust, gypsum and water. While those used to give whiteness are; alum, white-lead, lime, white clay, arsenic, plaster and chalk. Fortunately for Ameri-

cans, the most of these substances are reported by foreigners, for our American flours seem to be remarkably free from adulterations, as compared with those of the old country. In England, France and Germany, legislation on this subject has been very rigid. So the subject has been more carefully studied there than elsewhere. The millers and bakers of those countries seem to possess no conscience whatever, and had for years, before the government took hold of the subject, been in the habit of selling to the public, under the name of wheat flour,

Fig. 2. Potato Starch. Drawn with the Camera Lucida. Magnified 475 diameters.

anything whatever, without regard to its action on health. Some little time ago, in examining a suspected mill in England, 600 pounds of alum were found. Fortunately, the English people were saved from this inviting diet.

Adulterations occur more generally when the harvest is poor and grain is expensive. But it is a most remarkable fact that the very weather which will spoil wheat crops is the best weather to produce potatoes, so the first ingredient seized upon by millers to mix with wheat seems to be potato flour.

We have now some wheat flour, in which we suspect is potato starch or something else of a foreign nature. We will take up a little of the flour on the point of the penknife, placing it in a drop of water which has previously been placed on the glass slide and carefully covering it with the thin cover glass, when it is ready to study under the microscope. Examining some of the flour taken from several different parts of the specimen will generally be sufficient. This is the simplest and most convenient method of work, and does away with the long preparation, in which so many seem to delight. However, if very critical study of a specimen of flour be desired, perhaps the best method is that given by M. Boland, *American Miller*, August, 1878, page 183. Take a small amount of flour and add to it half its weight of water, to make a paste. Work this paste in the hollow of the hand, plunging it from time to time in a basin half full of water, slightly warmed. When lumps are no longer felt in the dough, wash the membraneous substance which remains in the hand under a stream of water, and when the water escapes clear the pure gluten is obtained. If there be any doubt of this, you have only to touch it with an alcoholic solution of iodine, and if it turns blue at the point of contact, starch is yet present; if it shows only a yellow color, you may be satisfied of its purity. Take the water used in washing the gluten, at the bottom of which a solid deposit has already been formed, and agitate it in order to place all the particles in solution again. Then pour it over a metal sieve into a conical-shaped glass vessel. Let the water which the vessel contains stand an hour. A deposit will then have formed in the bottom which must not be disturbed. Remove the water from this deposit with a siphon, and two hours later draw off the water again, which is still produced from the mass from time to time, until only a deposit remains, composed of two distinct layers. The upper one will have a grayish color, and is composed of gluten, of albumen, and of a sugary substance. The other layer will have a dull, white color, and is starch. Some time afterward carefully remove the upper layer with a teaspoon and allow the lower one to dry. The drying process may be facilitated by placing bits of blotting paper on the starch. When it is dry the starch

should be detached from the vessel, so as to preserve its conical shape. This little mass contains only starch, unless mineral or other adulterations be present. If it be all wheat starch, there will be no difference under the microscope between the specimens taken from the top of the cone or from the base. But if there be adulterations present they will consist of different weights and density, and they will be found in distinct layers parallel with the base of the cone. So the greatest care should be exercised in examining these different layers. If mineral substances be present they are found at the very tip of the cone, while in the layer next will be found the heaviest vegetable, which is probably potato flour.

In order to understand the difference between wheat and other starches, let us look again at wheat starch. There are two distinct kinds of starch grains found here; small, spherical or angular grains, collecting frequently in masses, many times more numerous than the large grains, about $\frac{1}{1000}$ of an inch in diameter. The others are large lenticular grains, which, when viewed on the face, appear like a spherical body, but when viewed on the edge, are like a double convex lens in shape. They are just like two saucers, set with their faces together. This lens shape can easily be proved by touching the cover-glass gently, while under the microscope, with a pencil point, and watching the grains roll over in the field, presenting first the appearance of a sphere and then a lens. This simple test should always be used when working out the adulterations of any flour or spice. There is seldom any nucleus present, when it is present though it will be found near the center of the starch grain. Still more seldom are there any rings to be found. According to one writer, Dr. Julius Wiesner, Professor in the University of Vienna, there is a compound starch grain present in the central part of the outer layer of albumen and made up of from two to twenty-five individual granules. These compound grains are very seldom found in either the flour or in the commercial wheat starch. When found they are elliptical or egg-shaped, and frequently much larger than the lenticular grains. The large starch grains of wheat in their natural or normal state are very uniform in size for the same variety of wheat, but the

grains found in the different varieties of wheat differ considerably in size. The average size is about $\frac{1}{1000}$ of an inch in diameter. Now if the specimen of flour be pure, we will have only these grains, together with minute particles of nitrogenous substances and occasionally broken fragments of the structure of the wheat. All of which are represented by illustrations in the *American Miller* of April, 1880.

Potato Flour.—See figure 2.—If it be not convenient to obtain the commercial starch, the fresh starch grains can easily be obtained by cutting a potato with a clean knife, and then floating on the glass slide, with a drop of water, the white substance which adheres to the side of the knife, and this will be the object desired. Or you may shave off a very thin section of the potato and place it in a watch crystal in a little water; the fine sediment settling to the bottom will be the starch. The grains are round, irregularly oval, or egg-shaped, and nearly transparent. The nucleus is not in the center of the grain, but generally quite near the smaller end, and it is always surrounded by numerous distinct rings or laminæ. In specimens which have been subjected to even a slight degree of dry heat, there appears a black line or star-shaped mark over the nucleus. The heat evaporates the moisture from the grain and there must be a shrinkage on the surface to correspond with the evaporation. This is the greatest over the nucleus where is the greatest moisture. The grains are very irregular in size, the smallest are just perceptible, and the largest are frequently $\frac{1}{300}$ of an inch in length, and large enough to be seen with the unaided eye. A very decided cross is seen when viewed with polarized light, the arms of the cross radiating from the nucleus of the grain and not from the center as it does in some other kinds of starches.

This is the cheapest and therefore the most common of all the substances used for adulterations both of wheat flour and of the spices. There are from $800,000 to $1,200,000 worth thrown upon the market annually from the New England States, and probably the most of it is used for adulteration.

Potato flour is considerably heavier than wheat, so in examining the different layers of the little cone composed of the sediment *it* would be found, if present, in a layer beneath

the wheat, that is, near the tip of the cone. It is more readily acted upon by a weak solution of potassic hydrate than wheat. The solution should be 1.75 parts of potassic hydrate with 100. parts of distilled water. This expands potato starch while it does not seem to affect wheat. The potato starch grains swell up to an enormous size, frequently fifteen times their original dimensions, while the rings are entirely destroyed which gives them a flake-white appearance. A weak solution of iodine will affect potato starch much quicker than it will wheat. Still both the potassic hydrate and the iodine will affect the wheat starch, although the statement has been made several times that such is not the case. The truth of this can easily be proved by trial. Nitric acid has the property of coloring flour an orange yellow while it does not change the color of potato starch. If the specimen of flour be adulterated with potato starch it will not assume the same bright yellow color which pure flour has on the application of nitric acid.

The presence of potato starch may generally be detected, even with the unaided eye, by the minute glistening appearance or the scintillations which are so characteristic of potato starch. The structure of the potato itself is very simple, the whole of the central part being made up of large hexagonal cells with very thin walls, and they are packed full of starch. A very good idea of their appearance is obtained from the illustration of the hexagonal cells of wheat, Fig. 5, page 118 of the April *American Miller*, 1880. So in addition to the starch grains when examined under the microscope, we occasionally see very delicate fragments of cellulose. Any person who intends making a study of this subject should become perfectly familiar with the appearance of potato starch under the microscope before he attempts to examine wheat flour for its adulterations.

Indian Corn, or maize, is one of the most common adulterations of wheat flour. The name corn is frequently applied to the fruit of all the cereals, and so it was used when mention was made of corn in the Bible and in Roman history, while Indian corn was known only after the discovery of America. The botanical name is *Zea Mais*, and belongs to the family of *Gramineæ*. It is a native of tropical America,

although it grows in the greatest abundance through the whole continent. It is found in its wild state in Paraguay and Chili. The cultivation of maize has within the last century increased to an enormous extent over the American Continent and throughout the most part of Asia, Africa, and Southern Europe. In the United States in 1870 there were raised 760,944,549 bushels of corn. It requires so little labor for its production, that it is among the most popular and cheapest grains cultivated, and consequently is produced by the poorer people of almost every country.

It is a most beautiful plant, and were it not so common it would be cultivated as an ornamental plant for the lawn and the flower garden. There are many different varieties of the foilage, some with broad leaves thrown off from a tall and stately plant, while others are dwarfs, growing only a foot, or a foot and a half high with beautifully striped leaves.

Some writers have claimed great antiquity, and an Eastern origin for maize; while others and able botanists have disagreed with them strongly. M. De Condolle says, "Maize is of American origin, and was not introduced into the old world until after the discovery of the new. It was found to be cultivated by the aborigines from New England to Chili." The poet Barlow has said the same, though in a different way:

> Assist me first with pious toil to trace
> Through wrecks of time thy lineage and thy race;
> Declare what lovely squaw, in days of yore
> (Ere great Columbus sought thy native shore,)
> First gave thee to the world; the works of fame
> Have lived indeed, but lived without a name.

Varieties not now in cultivation have been found in tombs of an antiquity greater than that of the Incas; and Darwin discovered "heads of maize embedded in a beach which had been upraised at least 85 feet above the level of the sea."

Recent analyses shows the following percentage of nutritive principles, as made by Dr. Dana:

Starch, oil, sugar and zeine	77.09
Nitrogenous matter, albumen	12.60
Water	9.00
Salt	1.31
	100.00

The ash contains a large proportion of phosphoric acid in combination with lime and other bases. The amount of fatty matter or oil is notable, varying with the kind of corn from six to eleven per cent. The hard flinty kinds of corn have the most, and the starchy kinds the least, oil.

Wheat contains about one and a half per cent. of fatty matter. The only objection to corn seems to be a deficiency of glutin or of nitrogenous substances as compared with wheat, for there seems to be no glutinous residue left when washed with water as there is in wheat. It is said by Gorham, to contain a red-

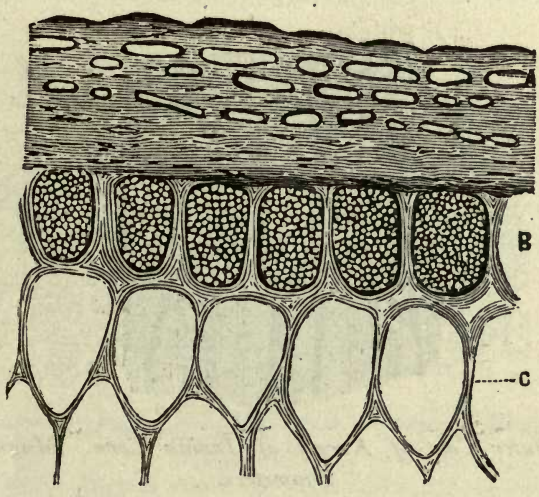


Fig. 3. Cross Section of a Kernel of Indian Corn. Magnified 350 Diameters. Drawn with the Camera Lucida.

dish nitrogenous substance, to which he has given the name *Zeine.*

The testa of the kernel of Indian corn, or the fruit and seed-coats are reduced to two only. The epidermis, or outer coat, consists of one row of longitudinally elongated, tabular cells, where the thick, coarsely dotted wall is noted for the bearded appearance of its margin. See Fig. 4. The inner coat is composed of six or seven layers of parenchymatous cells, all running in one direction, and about three times as

long as broad, having very strong walls. They are seen only in shadowy outline in Fig. 4. The outer layer of the albumen consists simply of one row of cells; thick-walled, nearly square and loaded with albuminoids. In Fig. 5 we see these cells as they have been cut off from the kernel parallel with the outside. While in Fig. 3, *b* we see them on a cross section. These cells are very similar to the albuminous cells of all the cereals as well as many other seeds. The central part of the kernel is composed of large thin-walled cells loaded with starch. See *c*, Fig. 3. A large white embryo occupies the whole of the lower part of the kernel.

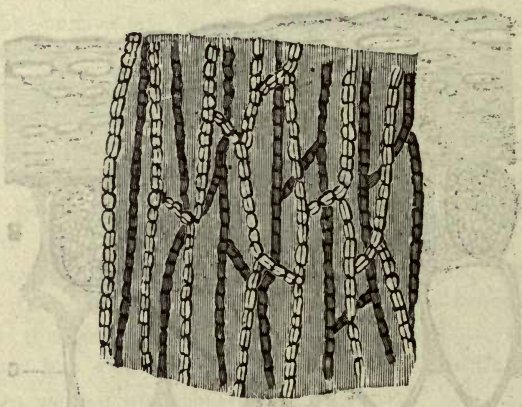


Fig. 4. Outer Coat of Kernel of Indian Corn. Magnified 200 Diameters.

The starch grains of corn (see Fig. 6), are generally bounded by plane faces and angles instead of curved faces, as in wheat and potato. There are no rings and no indications of any present. There is quite a depression at the center of each of the faces. This depression is quite common in the starches of oat, rice and buckwheat, as well as corn. In the process of drying, the center of the grain or the nucleus shrivels up in a peculiar and characteristic manner, which gives the appearance of stars or crosses on each of the faces, though it is sometimes only a little black spot. In fresh grains of corn starch this central depression together with the disc-shape

of some of the grains gives them a general resemblance to the blood discs of the mammalia, according to Hassell. The depressions are due to the evaporation of more moisture from the center of the grain than from any other portion. The starch grains developed in the outer part of the kernel of corn are much more angular than are those of the central part. The angular appearance of these grains is due to the way in which they are packed in the cells, each accommodating himself to his neighbor. So they look when taken out as soft pills would look were a number packed together in a small place. They are without a definite shape, and yet all having the same gen-

Fig. 5. Outer layer of Cells filled with Albumen. Magnified 200 Diameters.

eral appearance. They are never found forming definite compound bodies as in the oat and buckwheat, as we will see later.

The starch grains of Indian corn average about $\frac{1}{1600}$ of an inch in diameter, and there is quite a uniformity of size among the different grains as compared with the starch grains of potato.

When these starch grains are examined under polarized light well defined crosses are seen, the arms of the cross radiating from the nucleus at the center of the grain instead of from one side, as in the potato starch. When subjected to dry heat the shape of the grain is but little changed, while if

subjected to moist heat the shape is entirely destroyed. A solution of iodine turns the starch grains to a lighter blue, and potassic hydrate expands them like boiling water. The starch separated from all other constituents of the grain forms an important article of diet, which is sold under the name of "corn flour." While "corn starch" is proverbial for its laundrying properties.

It is estimated that maize is eaten by a greater number of human beings than any other grain, excepting rice. Its analysis shows it to be admirably adapted to sustain life, and to furnish material for the growth of both human beings and

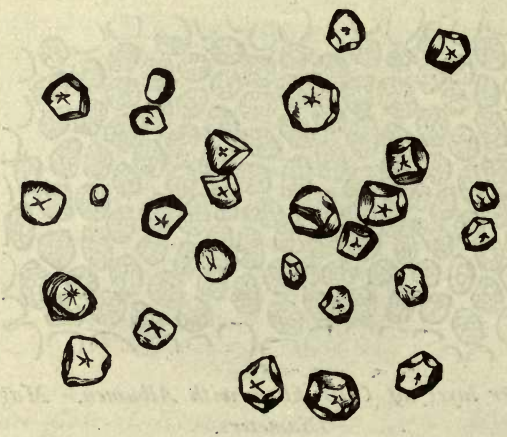


Fig. 6. Grains of Corn Starch. Drawn with Camera Lucida. Magnified 475 Diameters.

domestic animals. For maize is a highly concentrated nutriment, and is capable of serving, as it does in some tropical countries, as almost the sole food of the population. It is a most common article of diet with all Americans, and, on account of its cheapness, is within the reach of the poorest. It has been estimated that, if cooked in the right way, a meal can be made from corn costing only one-half a cent a person. In the Southern States it constitutes a primary article of food, for rich as well as poor, old as well as young. In all of its various combinations, it belongs to the table as do the

dishes themselves. It enters into the dietary of many of our public institutions and charities. Although it is used to such an extent among the farming population, it is little used in the cities, except as a relish. As "green corn," the supply furnished to the cities is perfectly enormous. Perhaps there is no article of food which is capable of being served in such a great variety of ways as corn. Hominy, hulled corn, pop-corn, and corn meal; while hasty pudding is far from being the least, and whose praises were sung in verse :*

"Some tawny Ceres, goddess of her days,
First learn'd, with stones, to crack the well-dry'd maize;
Through the rough sieve to shake the golden show'r,
In boiling water stir the yellow flour—
The yellow flour, bestrew'd and stirr'd with haste,
Swells in the flood, and thickens to a paste,
Then puffs and wallops, rises to the brim,
Drinks the dry knobs that on the surface swim;
The knobs at last the busy ladle breaks,
And the whole mass its true consistence takes.
Thy name is *Hasty Pudding!* thus our sires
Were wont to greet thee fuming from their fires;
And while they argued in thy just defense,
With logic clear they thus explain'd the sense :—
In *haste* the boiling cauldron o'er the blaze,
Receives and cooks the ready-powdered maize;
In *haste* 'tis served, and then in equal *haste*,
With cooling milk, we make the sweet repast,
No carving to be done, no knife to grate
The tender ear, and wound the stony plate,
But the smooth spoon, just fitted to the lip,
And taught with art the yielding mass to dip,
By frequent journeys to the bowl well stor'd,
Performs the *hasty* honors of the board."

Corn is used as fuel in many localities, upon prairie farms, where wood and coal are expensive; while corn cobs are a favorite for kindling wood on almost every farm. It is said smokers like a pipe where the bowl is made from a corn cob. Then the stalks and the leaves are of great value as cattle fodder, while corn is often sown for the sake of fodder only. The leaves of this plant have been manufactured into paper. An

*Written by Joel Barlow, Minister Plenipotentiary to France, in 1793.

Austrian, Von Welsbach, invented a process by which the fibers of the stalk, leaves and husks could be converted into paper. The juice of the stalk, before the grain ripens, has been converted into sugar and syrup, although it cannot compete with sorghum; so, indirectly, alcohol and whisky are produced from the plant. The oil is in such large quantities that it has been utilized for illuminating purposes. It is so very expensive ex-

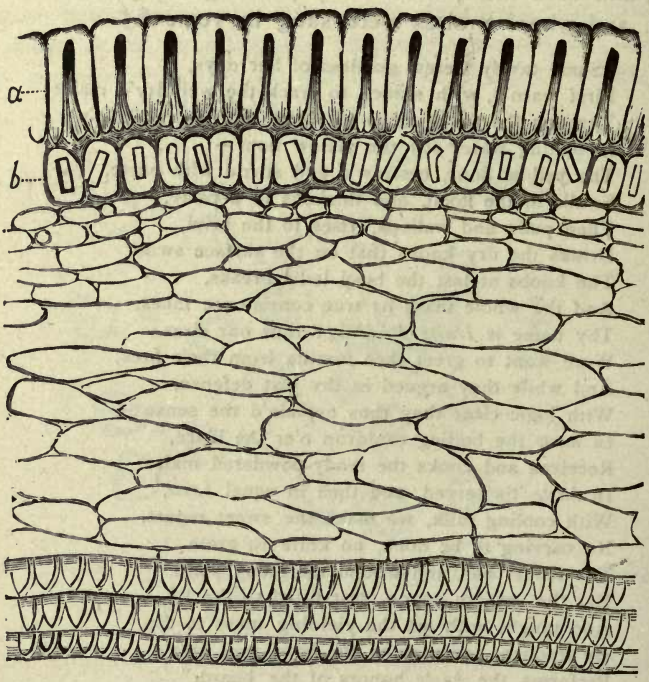


Fig. 7. Cross Section of the Coats of Bean. Drawn with the Camera Lucida. Magnified 400 Diameters.

tracting the oil, that it probably never will have general use as an illuminator. The leaves are used for upholstering purposes, husk mattresses being quite common. The more delicate leaves of corn are plaited into fancy articles, and we have from these braids, matting, slippers, hats, horse-collars, etc.

Indian corn is met with, in the state of a coarse flour, in

the shops, under the name of "Polenta." It is frequently mixed with a poor quality of wheat, and sold under the name of "Wheat," or "Amylum." Even if it were as palatable, and more nutritious than wheat flour, yet a substitution always deserves the greatest condemnation.

Corn flour appears also in market under the name of maizena, maizone, etc. Recently the writer was called on to examine some so-called "Baby Food" that sold for seventy-five cents a pound. It was imported from France, and claimed to be made from the finest wheat flour. On examination it was found to be only corn starch.

Notwithstanding the fact that corn is so common, and so

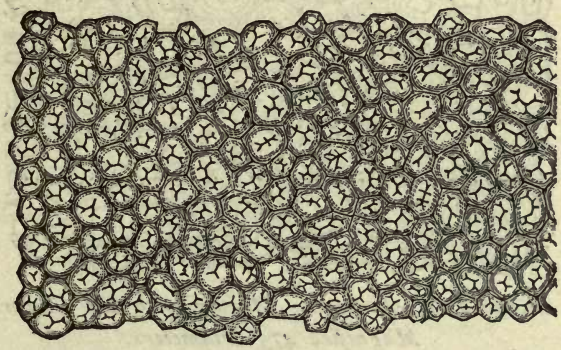


Fig. 8. Outer Coat of Bean. Drawn with Camera Lucida. Magnified 475 Diameters.

cheap, even this is subjected to adulteration. The most common substances used are beans, peas, oats, buckwheat, potatoes, and the other ingredients which have already been mentioned as forming a part of wheat flour.

Bean.—Among the most common adulterations of wheat flour is found bean. It seems to be a favorite ingredient for mixing with a poor quality of flour, and the very small class of millers who are in the habit of selling compounds to the public under the name of wheat flour, use bean flour quite extensively. It is cheap, wholesome, easily obtained, and makes a tenacious dough. The botanical name of our common bean is

Faba vulgaris. It belongs to the natural order *Leguminosæ*, and the sub-order *Papilionaceæ.* It has been cultivated in Asia and Europe since the earliest ages. It originated in the East, and is said to be still found wild in Persia. Although it dates from so ancient a time it is yet cultivated extensively over the whole world, and is used for food in all countries for men, cattle and swine. There are many different varieties cultivated and sold in market under various names, as Lima, Kidney, Winsor, black-eyed beans, etc. The Lima bean is extensively cultivated in America, and furnishes an important article of diet.

Fig. 9. Second Coat of Bean. Drawn with the Camera Lucida. Magnified 475 Diameters.

The common bean is either a running vine, trained on frames, bushes or poles, or a bushy shrub growing one or two feet high. It has pinnate leaves, without tendrils, and fragrant flowers. The seeds, which are the nutritious food, are inclosed in long pods, that are woolly on the inner surface. These pods, when green, and yet containing the soft green beans, are used for food. When fully ripe, the seeds are softened by soaking in water and then boiled or baked—baked beans having almost a world-wide reputation—or they are ground into a meal, thus making bean flour. The plant grows rapidly and luxuriantly, and it does not exhaust the soil, yet it requires a rich soil for its habitation. Beans are not cultivated to-day as extensively as they were before the introduction of

turnips and clover. It is supposed by many that the common bean is much more nutritious than wheat. It contains a high proportion of nitrogenous matter, under the form of legumin. It is, on this account, rather a coarse food, and difficult of digestion, although it is regarded as the best of food for horses, by many as far better than oats.

The Greeks and Romans regarded beans with very great interest. They were used by them as ballots at the time of the election of magistrates. Among them a white bean signified the affirmative, and a black one the negative. Ovid gives a description of an important custom which existed among the ancients. He says: "Beans had a mystic use, for the master

Fig. 10. Bean Starch after being Baked as in Bread.

a, Starch grains. *b*, Fragments of cell-walls.

of the family, after washing his hands three times, threw black beans over his head nine times, continuing to repeat the words, "I redeem myself and my family by these beans." Pythagoras urged abstinence from the use or contact of beans, and the Egyptian priests considered the sight even of beans to be unclean. Cicero used to maintain that beans were a great enemy to tranquility of mind.

There are three distinct coats surrounding the bean. The outer seed coat, as seen at *a* figure 7, the middle seed coat seen at *b*, and the inner coat, consisting of all the remaining structure. The first, or outer coat *a*, is made up of radially

elongated cells, having somewhat the appearance of teeth. These central openings that approach so near the top of the cell, are not of a uniform width, but are irregular, so if the section had been cut a trifle nearer either end of the bean, we should see some of the openings larger and some smaller than those seen in the illustration. The walls are thick, indicating a strong structure. The second or middle coat *b* is composed of thin-walled, nearly square cells, each cell containing a crystal. The crystals are of uniform shape and appearance, and stand up like sentinels in each cell. The third, or inner seed coat, consists of loosely packed, irregular, thin-walled cells. They are empty and collapsed, though they swell out when soaked in water. Below this layer, though forming a part of it, are found rows of beautiful spiral vessels.

All of these different structures are found in a cross section of the very thin coat or skin that rubs off so easily from beans after they have soaked in water a few minutes. It is this same skin that shrivels up or wrinkles when beans are first thrown in water. The way to secure a cross section for study under the microscope, is to take some of the thin skin from beans that have been soaking in water for several hours, and fold it together, so as to have four or more thicknesses, then place it between the smooth edges of elderberry pith and continue to cut very thin sections from the whole, until you have secured one so thin you can distinguish readily all of the different structures. A sharp razor or section cutter will be needed for making the section.

If from the outside of a bean which has been soaking in water for several hours, the outermost part of the skin be picked or cut off with a razor, we can see the surface of the outer coat, as in figure 8. The cells are now seen on the upper surface, and they are quite regular in size, surrounded with plane faces or angles, rather than being round, although they do not all have the same number of sides. Each cell is furnished with a central depression, and the center or lowest part of the depression seems to be a line broken abruptly, and the ends branching regularly, two at a time. This coat always presents a beautiful appearance under the microscope. It is

almost impossible to separate the outer and middle coats,—that is, *a* and *b* of figure 7. If the little specimen we have on the glass slide be turned over we shall see the surface of the middle coat, as seen in figure 9. This coat is composed of a single row of thin-walled cells, each containing its sentinel crystal.

The starch grains of bean are of particular interest, for they contain characteristics peculiar to themselves. The starch grains are oval or round, very similar in shape to the beans themselves. Then there is a central line or mark through the grain, corresponding to the mark on the back of the bean where it is

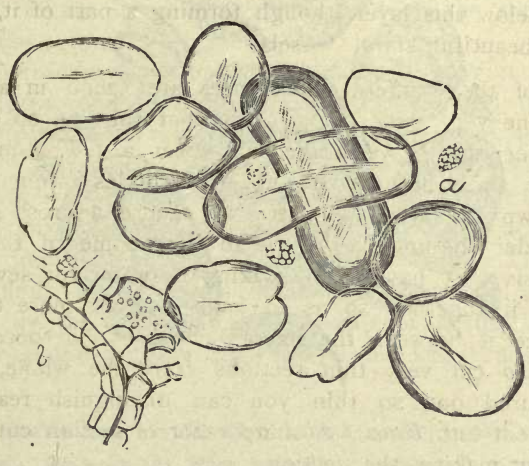


Fig. 11. Bean Starch after being Boiled, as in Pudding.

attached to the pod. This line is ragged and uneven in shape, though it marks the nucleus. So great is the resemblance to beans that persons in looking at the starch seem to think they are looking through a glass dimly at the beans themselves. Near the edge of the starch grain, but seldom extending to the center, are seen dark rings, quite fine and numerous. The grains average $\frac{1}{600}$ of an inch in length, and $\frac{1}{1000}$ of an inch in width.

When the starch grains of bean are subjected to a high degree of heat, but with no moisture present, the grains be-

come brittle, and the nucleus is destroyed ; the rings are not affected, but the edge becomes broken and ragged. Bean flour will seldom be subjected to an intense dry heat. In all kinds of baking, and in the treatment of the flour wherever heat is used, there is more or less moisture accompanying it. Where there is an extreme moist heat there is a great change produced in the starch, but not enough to destroy its identity. A microscopist can detect the presence of bean starch when mixed with wheat, even after it has been baked into bread. Figure 10 gives us the appearance of bean starch after it has

Fig. 12. Cells of Bean loaded with Starch and Glutin. Magnified 475 Diameters. Drawn with the Camera Lucida.

been baked. The moisture of the dough has caused the grains to expand slightly, while the heat has rendered them brittle and ragged. The nucleus and rings are slightly affected. At *b* some of the cellular structure appears.

In figure 11 we have some of the starch grains after they have been boiled in a pudding. They show very little resemblance to the original grain, yet it is sufficient when you see a large quantity of the grains to identify them. They have swollen to an enormous size, have lost their rings, though they retain their nucleus as well as their general shape. At *b* can

be seen how great a change is produced in the wall of cellulose by boiling. It would be impossible with any one starch grain, or with even a small number, to tell definitely just what treatment the starch grain has undergone. It is only when you examine a large quantity, and even then you can not tell the extent of the baking or the boiling by its appearance under the microscope. The entire bean, after the thin skin is removed, consists of large cells loaded with starch and glutin. (See figure 12.) The cells are generally hexagonal, thick-walled, and quite large. There are only a few starch grains contained in each cell, as compared with the way the starch grains of wheat are packed in their cells. Lying close to the walls and filling up all the space between the starch grains, are the fine granules of glutin.

A microscopical examination of bean flour reveals all of the structures represented in the illustrations, and they are so different from the structures found in wheat, as to be easily identified. Nitric acid forms an important test for the presence of bean flour. Whenever wheat flour with which powdered beans are mixed, is brought in contact with nitric acid and ammonia, it immediately assumes a deep red color. The presence of bean flour, when mixed with wheat flour, may be detected generally by the peculiarly strong odor of beans, and by the darker or yellowish gray color which the wheat flour assumes.

Barley, Rye, Oat and Buckwheat.

Barley is found principally in the temperate region. There are four distinct species and from these many old varieties have been cultivated and new varieties are yet being developed. Barley is the most hardy of all the cereals, its limit of cultivation extending farther north than any other, and at the same time it can profitably be cultivated in some of the tropical countries. Pliny claimed that barley was the most ancient food of mankind. No less than three varieties have been found in the lake dwellings of Switzerland, in deposits belonging to the stone period. According to Professor Heer two of the kinds found there are the most common varieties of to-day. The smallest, the most common, and the most ancient known, is the *hordeum hextastichum sanctum*. The Goddess Ceres generally has ears of this variety decorating her hair, while it is also found stamped upon ancient coins.

Barley has formed an important article of food in some of the northern countries, but on account of its deficiency in gluten as compared with wheat, it can never be a popular flour for making bread. It has some redeeming qualities, however, for we are told the Greek athletes were trained on this diet. As to importance both in an agricultural and commercial point of view barley is the grain crop ranking next to wheat. It is cultivated principally for malting purposes, and of all the cereals is the best adapted for this, containing as it does more starch and less gluten, and about 7 per cent. of ready formed grape sugar. Good barley should have a thin, clean, wrinkled husk closely adhering to a full, plump kernel, which when broken appears white and sweet, with a germ full and of a pale yellow color.

The fruit coats of a grain of barley differ considerably from those of wheat. There are four layers of longitudinally arranged

cells. The walls of the outer layer are wavy, but not beaded as in wheat. There are three layers of transverse cells and the walls are not wavy. There are also generally three layers of cells containing the gluten or nitrogenous substances. All of these cells are more delicate than the corresponding ones of wheat. The cells of the central part containing starch are also more delicate, and when empty resemble thin walled fibrous structure.

If we cut open a kernel of barley and scrape a little of the white powder from the center, we will find there are present two kinds of starch grains, both large and small. The large grains are lenticular; when seen on the face they are round or nearly so, but when seen on the edge they are oval, frequently showing a longitudinal furrow. A faint nucleus is present

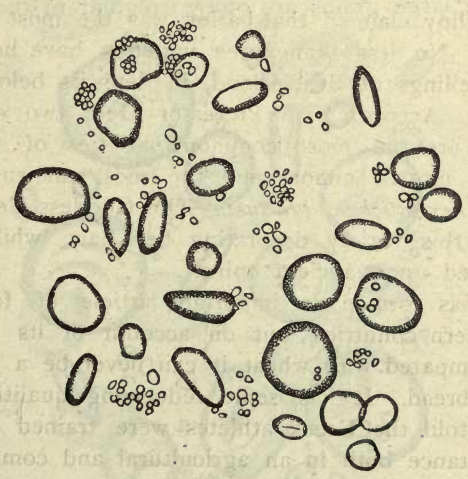


Fig. 1. Barley Starch. X 475. (*Drawn with the camera lucida.*)

and faint rings are seen in a few of the grains, though not in all of them. The average size is about one sixteen-hundredth of an inch in diameter. The small grains are angular, dark and not collected in masses as in many of the starches. The whole appearance of barley starch is much more delicate than that of wheat. The large grains are smaller, more nearly spherical and more opaque. The small grains are smaller, more uniform in size and fewer in number than the corresponding ones

of wheat. These small grains are one seven-thousandth of an inch in diameter, and frequently have a nucleus. There is no cross when viewed with polarized light.

Rye is probably a native of Southeastern Europe and Southwestern Asia. It has been cultivated for ages and is still grown in the most of temperate climes. Rye is frequently used as an adulteration of many of the commercial spices. Roasted rye is frequently found mixed with coffee, and has been reported as one of the ingredients found in wheat flour. Rye is obtained from *Secale cereale* and the kernels resemble wheat only smaller. The cells of the fruit coats are smaller, more delicate and more finely beaded than wheat.

There are two kinds of starch grains, large and small, found in rye. The large grains are quite irregular in their size, some

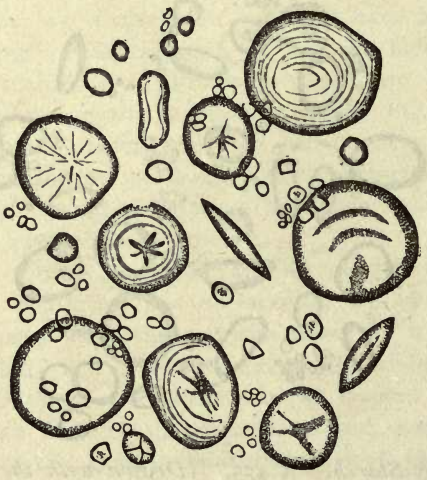


Fig. 2. Rye Starch. X 475. (Drawn with the camera lucida.)

being as small as barley, while many are several times larger than the largest grains of wheat. They are lenticular with a great difference between the two diameters, so when the grains are seen on the edge they are quite slender. The very large grains are flake-like, more transparent, devoid of rings, and frequently have several lines radiating from the central nucleus. Rings are seen in the smaller ones of the large grains, which

are more opaque and thicker than the others. The small grains are quite numerous and very small; they are smaller than the corresponding grains of wheat, while the large grains are very much larger. A strongly marked cross is seen with the polarized light in the large grains of rye starch.

Oat was formerly much used as food for man, especially in cool climates, where it is cultivated with the best success. Its native country is not certainly known, though probably Northern Europe or Asia. There are several distinct species of oats, the one generally cultivated in this country is *avena sativa*. Oat

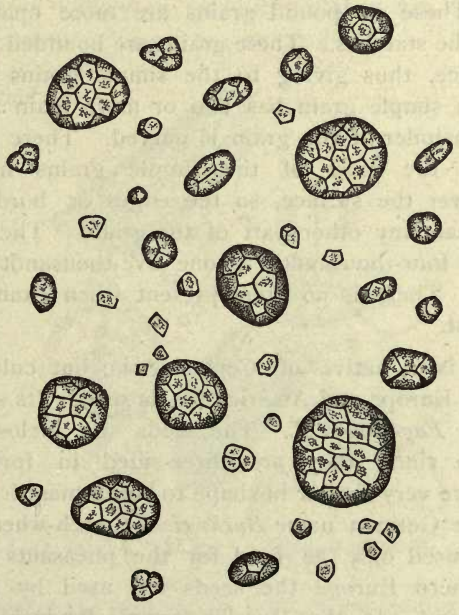


Fig. 3. Oat Starch. X 475. (Drawn with the camera lucida.)

flour does not form a dough or paste like wheat flour, so it can never be used as a substitute, although it is frequently mixed with wheat and sold under the name of wheat flour. Oat flour, however, contains a large amount of nitrogenous matter. The grains or kernels of oat are usually found in market inclosed in their husks. The first fruit coat of oat is com-

posed of several layers of cells. The cells of the first layer are large, long and bordered with thin beaded walls. From the cells of this outer layer of the first fruit coat, and from any point on its surface, arise long epidermal hairs, always turning toward the apex of the grain, where they are much more numerous.

Oat starch is composed of both compound and simple grains. The compound grains are oval, egg-shaped or spherical, and are composed of from three to twenty grains. The dividing lines between the single grains show quite distinctly. They are from one two-thousandth to one eight-hundredth of an inch in diameter. These compound grains are more opaque than the majority of the starches. These grains are bounded by a smooth, curved surface, thus giving to the simple grains their peculiar shape. Each simple grain has two or more plain faces or sides, while the remainder of the grain is curved. There is no nucleus present, but the most of the simple grains have a slight depression over the surface, so the edges or borders are more prominent than any other part of the grain. The small grains are from one four-thousandth to one five-thousandth of an inch in diameter. There is no cross present when examined with the polarized light.

Buckwheat is a native of Central Asia, but cultivated extensively in Europe and America for its seed. Its scientific name is *Polygonum Fagopyrum L.* The seeds are inclosed in a dark brown tough rind; they are three-sided in form with sharp angles, and are very similar in shape to beech-mast from which fact it derives the German name *Buchweizen* (beech-wheat). In Great Britain it is used only as food for the pheasants and poultry, but in Northern Europe the seeds are used by all classes of people for food. In the Russian army, buckwheat is served out as a part of the soldiers' rations. It is used to some extent throughout the United States for food. Buckwheat is poor in nitrogenous substances and fats as compared with the other cereals. It is a favorite crop for very poor land, as it grows with great ease and rapidity. Buckwheat flour is frequently found mixed with the poor qualities of wheat flour. Its color and properties prevent it ever being substituted for wheat flour.

Buckwheat starch (Fig. 4) is composed of both compound

and simple grains. The compound grains or masses are either cylindrical or prismatic. When cylindrical the curving surface is perfectly smooth, but the ends are irregular as though they had been broken. These masses are very numerous and characteristic, unfortunately they closely resemble the cell contents of black pepper. These compound grains are much larger than those of oat. They are quite opaque and show distinctly the divisions into small, single grains; many of the small grains are like the corresponding ones of oat in having two or more plain sides and the remainder of the grain curved. They are larger than oat, being one three-thousandth to one sixteen-hundredth of an inch in diameter They are quite irregular in size, and generally a nucleus is present. There are no rings.

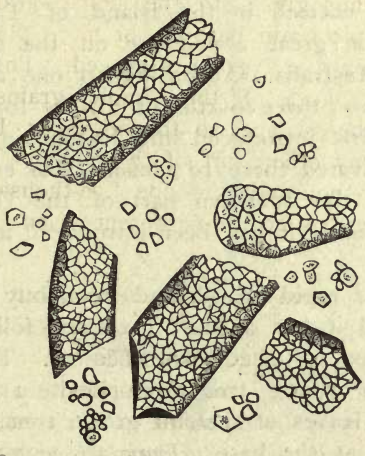


Fig. 4. Buckwheat Starch. X 475. (Drawn with the camera lucida.)

If you suspect the sample of flour which you are examining contains either oat or buckwheat, it will be much easier to examine it first with a low magnifying power (something less than 150 diameters) and decide the question of the compound grains or masses first, then examine it with a higher power. Fortunately for humanity the best qualities of flour are almost invariably what they profess to be, "pure wheat flour." The mixtures and adulterations of other flours and too often mineral substances are found in the cheapest, poorest flour in market.

EUCALYPTUS GLOBULUS.

CONSIDERABLE interest has been excited lately on the subject of a new remedy which bids fair to rival for malarial troubles the old stand-by, quinine. This specific is known scientifically as *Eucalyptus globulus*, and commonly as blue gum-tree. It belongs to the natural order Myrtaceæ.

It was first noticed in the island of Tasmania in 1792, while it grows in great abundance on the moist slopes and woody hills of Australia. According to one author, a Frenchman, it constitutes three-fourths of all the forests of that continent. It was first introduced into Europe in 1856, since then it has been cultivated there to considerable extent, and also in northern Africa, the southern part of the United States and California. Recently it has been introduced into Italy in large quantities.

The tree is a rapid grower and frequently attains the height of 300 feet, and it has a most luxuriant foliage which makes it a beautiful tree for shade or ornament. The leaves of the plant or of the young tree are opposite and cordate at the base; while the leaves of the full grown tree are alternate and slightly rounded at the base. They are very long and slender, generally curved or crescent shaped and tapering at the apex to a long acute point. They are from 8 to 15 inches in length and in their broadest part only from ½ to 1½ inches in width. There is a prominent, coarse mid-rib present, with secondary ribs running the entire length of the leaf parallel with and very near the margin, while the margin is entire and smooth, being protected by a thickened wall of cellulose. Both the upper and under surfaces are dotted with prominent glands filled with resin or with oil. The leaves are of a yellowish green color, while the midribs, veins and margin are white. They are of a leathery consistency, with a peculiar, strong odor of pine and an

Fig. 1—Eucalyptus Leaf.

aromatic, pungent taste, slightly bitter, followed by a sensation of coldness.

The microscopical structure of the leaves is quite characteristic. A cross section, when magnified only a few times, shows the large resin-cells loaded with bright brick-red resin and the smaller oil glands in which float the oil drops of a bright yellow color. When magnified more highly the minute structure of the leaf is seen plainly. In figure 2, we have a cross section of the leaf cut directly through the midrib. The midrib is composed mostly of wood and liber fibre which gives such great strength to the frame work of the leaf. On the upper and under surface, and in fact entirely covering it, is a very thick wall of cellulose which is nearly impervious to water and to the sun's rays; at A we see this thick wall that stands duty over

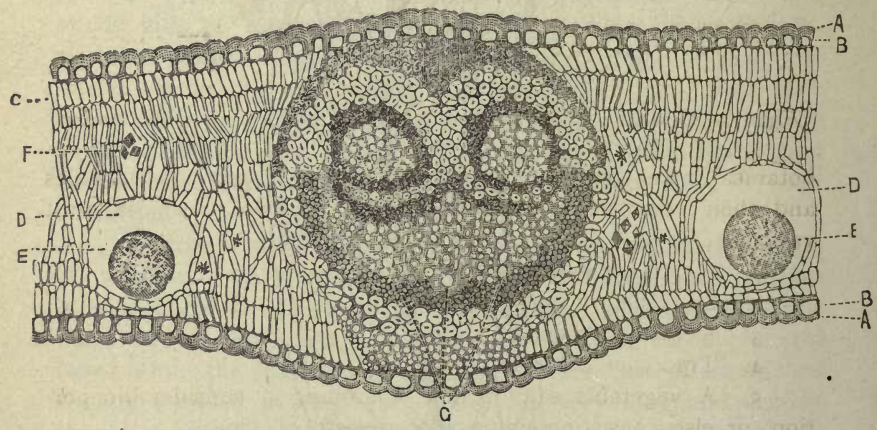


Fig. 2.—Cross Section of an Eucalyptus Leaf. x50 diameters.

the delicate central portion. The epidermis seen at B is a single row of empty cells whose only object in life apparently, is to give a chance for the circulation of air between the outer garment of cellulose and the body of the leaf. The green portion of the leaf is composed entirely of the delicate elongated cells loaded with coloring matter called chlorophyll, while to the row of cells seen at C has been given the imposing name of palisade cells. Palisade cells are common to all leaves.

Some of the large oil glands so numerous in the leaf, are seen at D containing yet a drop of oil, E. The whole leaf is loaded with the most beautiful crystals; see F. Some of these crystals separated from the leaf and greatly magnified are seen in figure 3. The prismatic crystals are calcium oxalates. The

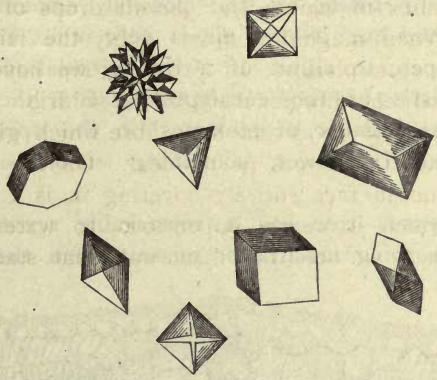


Fig. 3.—Crystals from the Leaf of Eucalyptus. x750 diameters.

botanical name for the rosettes of pointed crystals is raphides and their composition according to Dr. Lionel Beale is most various :

1. A little organic matter.
2. Sulphate of lime.
3. A little carbonate of lime.
4. Traces of chloride of sodium.
5. A vegetable salt of lime containing a considerable portion, or else consisting entirely of oxalate of lime.

The virtue of eucalyptus depends upon a volatile oil; of this oil the fresh leaves yield 2.75 per cent., and the recently dried leaves yield 6 per cent. This oil is composed of two camphors, the larger proportion of which is known as eucalyptol.

The leaf is supplied with quite large stomates or breathing spores or mouths; see figure 4. These stomates connect directly or by means of little openings between some of the palisade cells with the center of the leaf, so that air and moisture are carried all through the leaf between the loosely packed structure, until it reaches the end of a spiral vessel.

The spiral vessels are the connecting links between the air of the outside world and the roots of the tree. In making the cross section of the leaf some of the spiral vessels were cut across and can be seen at C figure 2. When the atmosphere around the tree is very dry you will find these stomates closed tightly so as to retain all the possible amount of moisture within the plant; but if the air is very moist these stomates will be wide open, to admit of a free circulation. A remarkable characteristic of the eucalyptus leaf is the presence of nearly the same number of stomates on the upper surface of the leaf, as upon the lower, something uncommon except in water plants.

The eucalyptus tree has a remarkable reputation just at present, for absorbing malaria or miasma from the surrounding

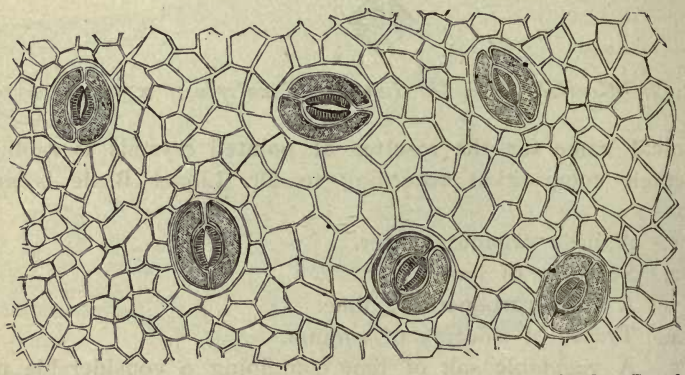


Fig. 4. Stomates from the Upper Surface of the Leaf. x250. Drawn with the Camera Lucida.

atmosphere. So large tracts of land in the Campagna di Roma have been devoted to raising a forest of eucalyptus trees. Some advanced botanist has suggested this virtue of the tree was due to the great number of stomates on the leaves, and it seems a safe theory to adopt.

Through southern California the eucalyptus trees are being systematically cultivated for fuel. Two hundred and twenty-five trees are generally planted to the acre and it is estimated that

two acres of the growth will supply the family constantly for fuel. Fresh growths start much more rapidly from the old trunks, that were left after cutting the trees down, than from fresh plants. Ten acres of this tree were planted in Alameda county, California, which at the end of seven years netted $1,190, and there were left 1,000 of the largest trees that will in a few years develop into some of the best kinds of wood for manufacturing purposes.

Some very fine specimens of Eucalyptus leaves were furnished me for this article by Parke, Davis & Co.

Jaborandi. Pilocarpus Pennatifolius.

Pilocarpus pennatifolius was first found in the southern provinces of Brazil. It was introduced from there into Europe in 1874, where it is now cultivated in the various botanical gardens on the continent and in England.

It belongs to the order Rutaceæ, and to the tribe Xanthoxylaceæ, to the genus Pilocarpus and species Pennatifolius, while the common name is Pernambuco Jaborandi.

There has been in the past considerable confusion regarding the botanical position of Jaborandi. Dr. Peckolt has described seven different kinds of plants sold at the stores of Brazil under the common name Jaborandi. Four of these belonging to the Piperaceæ order, two to the Rutaceæ, and one to the Xanthoxylaceæ. Martinus has described still more. The Jaborandi, under consideration in this article, was introduced to the notice of the medical profession in Europe by Dr. Coutinho, of Pernambuco, in the spring of 1874. Since then it has been tried by many leading physicians in both Europe and America. It was in 1875 that Prof. Baillou, of Paris, referred it, from the examination of the leaf alone, to the genus Pilocarpus, and still later that Mr. Holmes, by an examination of the fruit, named it P. pennatifolius. The leaves and young shoots are the parts used as officinal, though it is not recognized in either the British Pharmacopœia or in the Pharmacopœia of the United States or of India.

DESCRIPTION.

Jaborandi is a small shrub, four or five feet high, only slightly branched, and the branches standing erect. The bark is smooth and gray in color, with numerous white dots covering its surface. The leaves (see fig. 1) are very large and compound. They are alternate, without stipules, and with long stalks, from a foot to a foot and a half in length. The leaflets are generally opposite, in

two to five pairs, and with a terminal one. The leaflets are three-and-a-half to four inches long, are oblong-oval, with pointed bases. They are very obtuse, rounded or notched at the apex. The margins are entire, rolling slightly backwards. The dried leaves are leathery in texture, smooth, free from epidermal hairs and glands, and of a bright brown on the upper surface. The fresh leaves are of a bright shining green on the upper surface, but much

Fig. 1. Pilocarpus Pennatifolius. a. Upper surface of the leaf. b. Lower surface. c. A part of the flower stalk with the flowers. Natural size.

paler on the lower surface, which is crowded with minute dots. These dots show as clear, nearly white spots, when the leaf is held between the person and the light. (See b, fig. 1.)

The long stalk bearing the flowers is from eighteen inches to two feet in length, being thickly covered with small flowers and buds. The illustration shows only a small piece of the flower stalk. (See c, fig. 1.)

MICROSCOPICAL STRUCTURE.

The cuticle is thick and granular, rather than smooth, apparently containing something besides cellulose. (See a, fig. 2.) Directly beneath this is a single layer of epidermal cells (b). The palisade cells (c) are longer and more slender than the average, and loaded with yellow chlorophyll and dead protoplasm. The cells of the loosely packed parenchyma are thinner walled and are more scattered than usual. They are nearly empty. Some of the smaller cells contain a pale, pink-colored oil, thin and clear ; while the oil drops, which are found floating around loosely, are of a

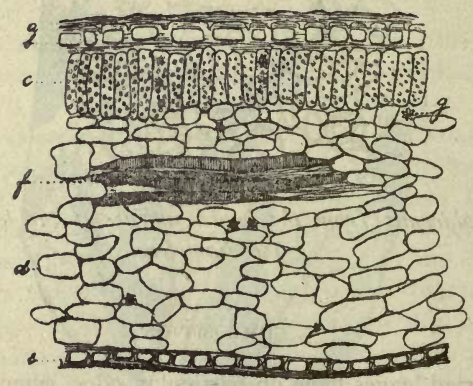


Fig. 2. Cross section of the leaf of Pilocarpus Pennatifolius. Magnified 250 diameters.

bright yellow, but rendered nearly opaque by the presence of a fine black granular substance. The lower epidermis (e) is smaller and more delicate than the upper. A small fragment of one of the veins or a vascular bundle, showing spiral vessels, is seen at f. There are numerous large stellate crystals found all through the structure of the leaf, rather than on either side of the vascular bundle, as is generally the case. Some are found even between the palisade cells and the upper epidermis. The crystals are of calcium oxalate. The minute dots seen on the under surface of the leaf are internal glands or large openings found on the inside of the leaf. They are always found among the loosely packed parenchyma, and connecting with the outside through a minute opening on the lower surface of the leaf. These contain a dark yellow

resin-like mass. But the mass does not entirely fill the gland. Occasionally small masses of resin are found scattered through the leaf.

Fig. 3 shows the epidermal cells from the lower surface of the leaf when magnified 250 diameters.

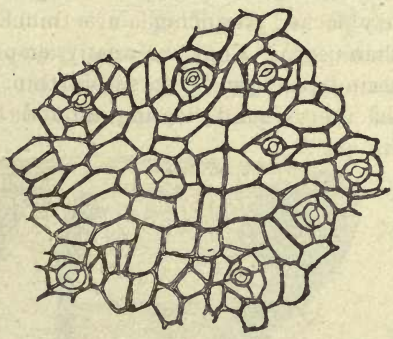


Fig. 3. Epidermis from the lower surface of the leaf. Magnified 250 diameters.

COMPOSITION.

The dried leaves have no particular odor when unbroken, but they have a perceptible aromatic odor when broken. Martindale says the odor "resembles a mixture of Indian hemp, matico and cubebs." The taste is feeble at first, but on chewing it is somewhat aromatic and bitter. At first it produces a warm, tingling sensation in the mouth, accompanied by an increased flow of saliva. The bark has a similar taste and odor as the leaves, but is more pungent. Rabuteau, who has experimented considerably with the leaf, believes the odor is due to a volatile principle, but not analogous to the essential oils contained in aromatic plants; and the bitter taste to a principle soluble in water and alcohol. Since then Gerrard and Hardy have proved the presence of an alkaloid, which they have proved possesses well-marked chemical and physiological properties. It is soluble in water, alcohol and chloroform. This alkaloid is regarded as the active principle of Jaborandi, and has been named Pilocarpine or Pilocarpia.

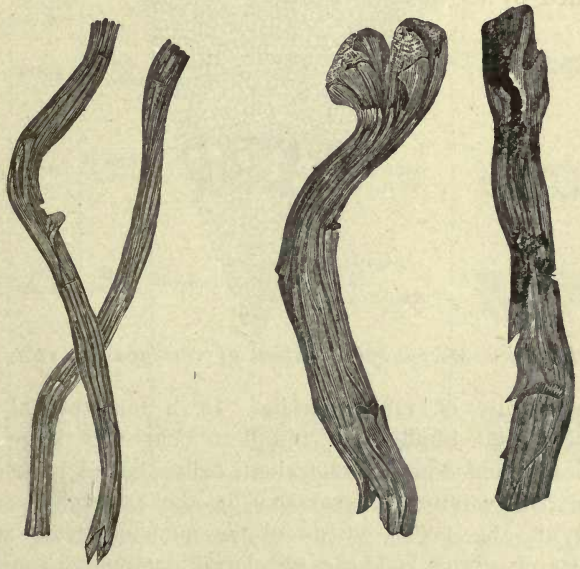
Besides pilocarpine, Jaborandi contains a volatile oil and various salts.

PROPERTIES AND USES.

Jaborandi has been proved by a number of observers to be a valuable diaphoretic. Pilocarpine has been found by some to be specifically antagonistic to atropia. Murrell concludes that the alkaloid is capable of producing, in a much smaller dose, the full effects of the drug itself. Harley states "that diseases associated with or dependent upon imperfect action of the salivary glands and the skin, are those which we may expect to be benefited by its use."

SARSAPARILLA.

SARSAPARILLA is of the genus *Smilax*, and is found a native of the northern part of South America and the whole of Central America. It is a woody climber and supports itself in



Honduras Sarsaparilla. Fig. 1. Jamaica Sarsaparilla.
(Natural Size.)

climbing by strong tendrils which spring from the stem of the leaf. The rhizome is short, thick, knotty, from which grows, in a horizontal direction, the fleshy roots. These appear in commerce several feet in length and from one-third to two-thirds of an inch in diameter, cylindrical and flexible, with a thick external cortical portion. On a cross section of the root (see fig. 2)

its woody portion which is composed of fibro-vascular bundles, is found near the central part, surrounded by a brown ring or nucleus sheath, see A figure 2. Within this nucleus sheath the bundles are so densely packed as to form a woody zone. The very centre of the section consists of white pith. Occasionally an isolated fibro-vascular bundle will be found. Outside the nucleus sheath we find the same structure as the pith, simple parenchyma. There is no bark proper, but in its place

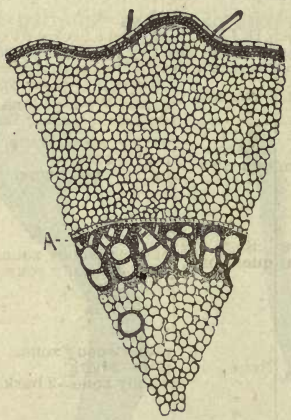


Fig. 2. Microscopic Section of Sarsaparilla root.

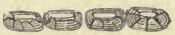
a thin epidermis of tabular cells. In a longitudinal section the fibro-vascular bundles are found to consist of large scalariform vessels and long thick-walled cells, called prosenchyma. In two of the varieties of sarsaparilla the parenchyma of the pith and all the cells outside of the nucleus sheath are loaded with starch grains. These are large compound grains $\frac{1}{2000}$ of an inch in diameter. Some of the cells contain needle-shaped crystals of calcium oxalate. In two varieties of sarsaparilla which do not contain starch, the prosenchyma and the vessels contain a bright yellow resin. The principal structure of interest in the whole texture of sarsaparilla is the brown nucleus sheath seen at A, fig. 2. This little narrow row of cells seems to be the guide by which the different varieties are determined, for each cell is characteristic of the variety to which it belongs. Each individual cell may be tabular and

tangentally extended, as seen in Honduras sarsaparilla, or they may be narrowly oval, as seen in the Mexican variety.

The secondary deposits may be uniform in width, as in Rio Negro sarsaparilla, or this deposit of cellulose may be found almost entirely on the inner surface, as in the Jamaica variety.

Below is given the differences, in a tabular form, of the four varieties of sarsaparilla which are recognized by the new National Dispensatory.

VARIETIES OF SARSAPARILLA.

Name.	Mealy or Not	Color.	Starch.	Width of Bark, Pith and Woody Zone.	Nucleus Sheath.
Honduras.	Mealy..	Pale brown.	Large quant'es	bark > woody zone. pith > bark. pith > woody zone.	
Rio Negro.	Mealy..	Orange brown.	Small quant'es	bark=pith. bark=4 woody zone. pith=4 woody zone.	
Mexican... *German P.*	Non-mealy.	Dull brown.	None	pith=woody zone. pith=2 bark. woody zone=2 bark.	
Jamaica... *British P.*	Non-mealy.	Red ...	None	bark=pith. bark=1½ woody zone. pith=1½ woody zone.	

The Honduras sarsaparilla see figs. 1 and table, may be taken as the typical variety. It is of a gray or light brown color, striped or slightly wrinkled, about half an inch in diameter. When a cross section of the root is made it exhibits a thick parenchyma, or, as it is commonly called, bark, loaded with starch. While the Honduras is the variety generally used in this country, the Jamaica is the only one recognized by the British Pharmacopœia, and the Mexican is the only one the Germans recognize as officinal. There are nearly 600,000 lbs. annually used in the United States.

Fucus Vesiculosus.

ONE can hardly take up a pharmaceutical or medical journal of the day without seeing something in it about the wonderful anti-fat remedy—*Fucus Vesiculosus*. The questions naturally present themselves, where is it from? what is it? how does it look? With these questions in mind, we will study it for a short time.

It is found in great abundance on the shores of the Atlantic, from Greenland to the Canary Isles, both on the American and on the European coasts. It grows where it can a part of the time be covered by water and a part of the time be dry, so it is found between tide marks on almost all of the rocks and stones. It lines our Western coast from Kamchatka to California. It is used in large quantities in making kelp, and in many of the European islands and in Scotland is used as fodder for horses and cattle; while, on our Eastern shore, it is sold by the wagon-load as a fertilizer. No satisfactory chemical test has as yet been made. It contains much soda in saline combination, and iodine in the state of iodide of potassium.

We find mentioned in part "D" of the United States Dispensatory that *Fucus Vesiculosus* belongs to the cryptogamic algæ in the sexual system, and to the natural order *algaceæ*. There can be a question raised at this point, as there is no natural order known in botany as *algaceæ*. It does belong to the sea weeds—*algæ*—and is found in cryptogamic botany. For the use of those who would like to trace it out we give below a synopsis of the general plan.*

The *Fucus* is from two inches to two feet in length, and from one half an inch to an inch and a half in width. It grows attached to rocks or stones by an expanded disc-shaped root. The

*Botany: Phænogamic or flowering plants; Cryptogamic or flowerless plants: Ferns, Mosses, Lichens, Fungi (molds, rusts, blights etc.); Algæ (sea-weeds): Chorospermeæ (green algæ), Floridеæ (red); Melanosporæ (brown): Phæsporeæ, Dictyoteæ, Sargassum, Fucus

Fucus has nearly a hundred varieties, the most prominent of which are vesiculosus, nodosus, serratus, fastigiatus, distichus, platycarpus, etc.

frond or leaf is flat ; the branches, irrespective of lateral displacements, all lie on one plane—though often twisted spirally—are thick, linear, and entire at the margin, branches by twos, is furnished with quite a prominent mid-rib. The air vessels, or blad-

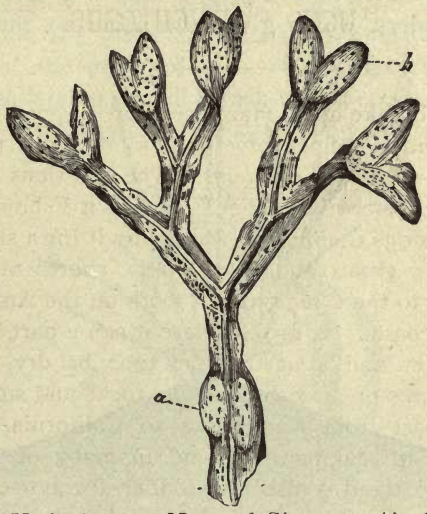


Fig. 1. Fucus Vesiculosus. Natural Size. a. Air Bladder. b. Fertile end of the Frond.

ders, are globose or elliptical, formed by inflation of the substance of the stem or branch ; are mostly found in pairs, though sometimes absent. The substance is coarse and thick. The ends of

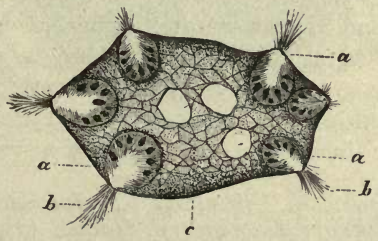


Fig. 2. Cross Section of one of the tips of Fucus Vesiculosus. (x 8 diameters.)

the branches are enlarged, forming bladder-like receptacles, having their surface covered with protuberances, ellipsoid, oval or spindle-

shaped, mostly in twos, as seen at *b*, fig. 1. It has a peculiar odor and a nauseous, saline taste. The reproductive organs are developed on different fronds. The fronds bearing the male organs are an olive brown, while those of the female are a reddish brown.

Fig. 1 shows a frond of *Fucus Vesiculosus*, natural size. The pair of air-bladders, which gives the name to the sea-weed, is

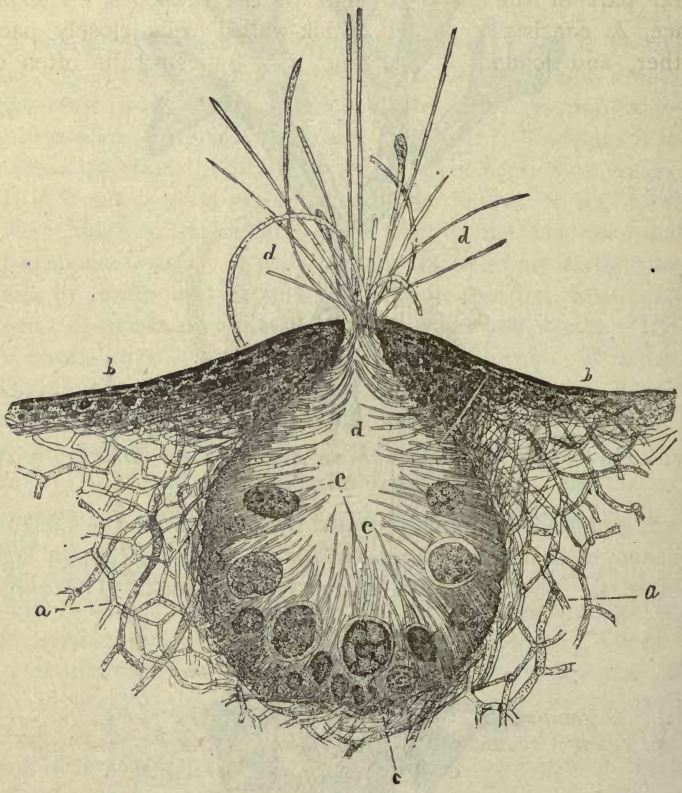


Fig. 3. Conceptacle, F. Vesiculosus. a. Interlacing Filaments. b. Epidermal Cells. c. Oogonia. d. Hairs. (x75 Diameters.)

seen at *a*. Generally all of the tips of the branches are enlarged and bearing, thickly crowded on the surface, the small conceptacles which contain the reproductive organs.

A cross section of the enlarged tip, seen at *b*. fig. 1, was

made, and the little protuberances or black spots on the surface showing at *a* fig. 2 are the conceptacles. There are six of them in the section showing different stages of perfection. The conceptacle in the upper right-hand corner of the illustration was more highly magnified and is seen in fig. 3.

A, fig. 3, are the interlacing filaments which fill up the whole central part of the enlarged ends of the branches. The outer surface, *b*, consists of small, thick-walled cells closely packed together, and loaded with mucilage. The cell-walls often con-

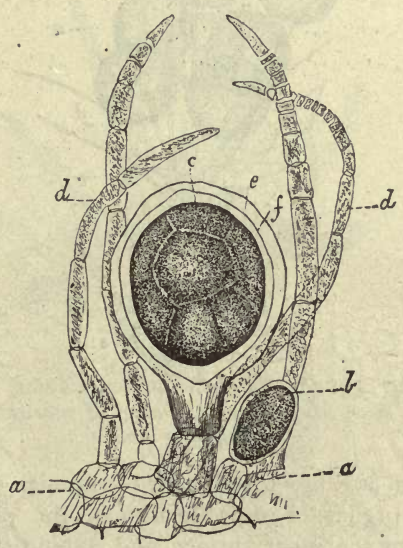


Fig. 4. Oogonium, F. Vesiculosus. a. Cells of the Inner Surface. b. Young Oogonium. c. Protoplasm. e and f. Membranes. d. Hairs. x200 diameters.

sist of two clearly distinct layers; the inner, firm, compact; the outer, gelatinous and capable of swelling greatly in water. These cells can be plainly seen with a magnifying power of 200 diameters, or when the surface of the plant is examined, but not distinctly on a cross-section. The cell contents is granular and has not been well investigated. The contents appear

brown, but contain chlorophyll, which is concealed by other coloring matter.*

We come now to the special object of interest to all botanists in this plant, which is the enlarged bodies found inside of the conceptacle. The whole object in life of these openings, or rather of the plant itself, is to produce, develop, and scatter the

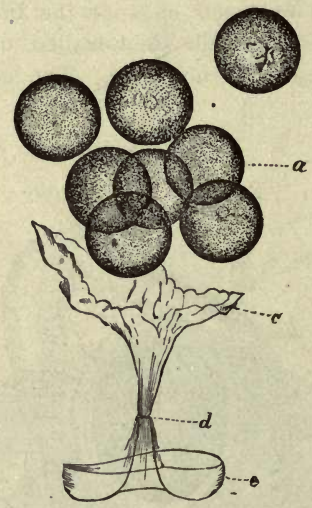


Fig. 5. Oospheres of the F. Vesiculosus. (After Thuret.) a. Oosphere. c. Inner Membrane. e. Outer Membrane. d. Point of Union of c and e.

dark bodies seen at *c*, fig. 3, and called oogonia. They correspond to the female organs of reproduction in the plant. At *d*, the hairs which line the inner surface and extend far out from the mouth of the conceptacle are seen.

Fig. 4 represents one of these oogonia magnified 200 diameters; *a*, cells forming the inner surface of the conceptacle, very thin-walled and filled only with protoplasm; *b*, a young oogonium not fully formed and showing only one sack or membrane covering it; *d*, shows four of the hairs—paraphyses—cover-

*In a recent paper (Comptes Rendus de l' Acad. des Sci., Feb. 22, 1869), Millardet showed that from quickly-dried and pulverized Fucaceæ an olive-green extract is obtained by alcohol, which, shaken up with double its volume of benzine, and then allowed to settle, produces an upper green layer of benzine containing the chlorophyll, while the lower alcoholic layer is yellow, and contains phycoxanthine. Thin sections of the frond, completely extracted with alcohol, contains also a reddish-brown substance, which, in fresh cells, adheres to the chlorophyll-grains, and can be extracted by cold water, more easily when the dried fucus has been previously pulverized. Millardet calls this reddish-brown substance phycophæine.

ing the inner surface of the conceptacle; they are long, nearly transparent bodies containing small quantities of protoplasm; *c* is the nearly ripe oogonium. Two distinct membranes or sacks appear at *e* and *f*. The central mass of protoplasm, as soon as it has attained a definite size, divides itself into eight distinct masses. About the same time that the protoplasm begins to divide, the membrane *e* is ruptured at the top, and the whole mass, with the second membrane, *f*, floats out. The eight

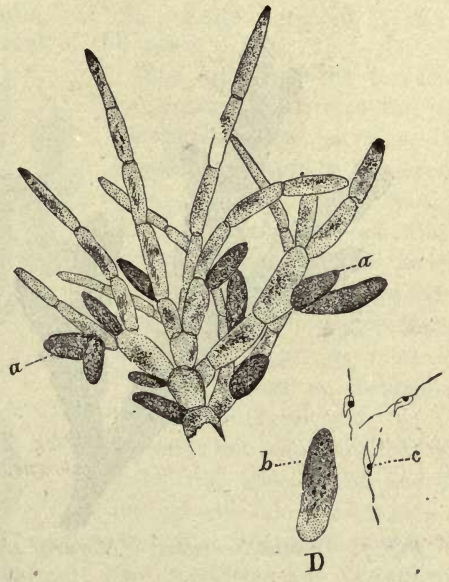


Fig. 6. Antheridia, F. Vesiculosus. a. The Antheridia. b. Some More Highly Magnified. c. Autherozoids. (400 diameters.)

divisions contract upon themselves, forming round bodies until they break through the two remaining membranes, and float out in the water as eight uniform, nucleated, perfect spheres, called oospheres, fig. 5. These are carried out of the conceptacle by means of these hairs, whose only object is to throw the oospheres from the conceptacle.

In the olive brown fronds of the *Fucus Vesiculosus* which resemble the one pictured in every respect, excepting in the

conceptacles, in the place of the oogonia we find little masses of protoplasm growing on the sides of the hairs, rather than at their bases, known as antheridia—or male organs of reproduction—as seen at *a*, fig. 6.

At D, fig. 6, we see one of the antheridia more highly magnified, showing the great numbers of antherozoids as they float in the water ; little pointed bodies with a distinct, bright red spot at one side and furnished with two very active cilia, one extending forward and the other back. The antherozoids are fully

Fig. 7. Fucus Serratus. Natural size.

developed at the same time the oospheres are thrown out of the conceptacle ; and there seems to be some attractive power in the oospheres, or in the paraphyses around the mouth of the conceptacle, for the moment the oosphere leaves its home it is attacked by swarms of the antherozoids. They seem to attach themselves firmly by means of the anterior cilia, while the posterior is in active motion. In this way they give to the oosphere a rapidly whirling motion, which lasts for nearly half an hour. It then becomes quiet, and very soon a change is seen. It is supposed that the oosphere comes to a rest so soon as an antherozoid forces its way through the membrane into the protoplasm ; the primitive change in the oosphere is a semblance

of a cepta, that gradually grows more distinct until it crosses the whole, when one-half of the fertilized oosphere puts out little protuberances which develop into roots, and the other half grows into an expanded frond that developes in its turn conceptacles, oogonia and oospheres, or antheridia, and antherozoid.*

[As a note to the excellent article of Mrs. Stowell's we give plates of the two most common varieties of the sea-wracks that are apt to be substituted for the genuine anti-fat one. The first, or Fucus Serratus, can be readily detected if any attention is paid to the contour of the leaves.

Fig. 8. Fucus Nodosus.
Natural size.

You will notice the leaves are dentated, or serrated, and from this fact it derives its specific name, serratus. It has no air vessels, or bladders, as seen in the genuine obese-reducing Fucus, which gives it its specific name Vesiculosus.

The other common variety, and one most apt to be confounded with the F. Vesiculosus, is the Fucus Nodosus, as seen in the accompanying plate.

This knotted, or clubbed-wrack resembles considerably the genuine medical variety, but can be distinguished from it by the absence of any mid-rib, and the vesicles along each side of the mid-rib. Any enlargement the Nodosus has, that simulates the Vesiculosus variety, is a bulbous enlargement of the whole frond.

The common name, "wrack," which all these species of sea-weed bear, is derived from the Channel Island vernacular, where it is known as *vraic*, a *patois* of the French *varec*, which means "sea-weed." Another vernacular name for the Fucus Vesiculosus is (from its color) "Black Tang."—EDITOR OF LEONARD'S JOURNAL.]

*Authorities—Harvey, Neries Boreali-Americana. Sach's Botany, page 227. Thuret, Ann. des Sci. Nat., Ser. IV., Tom. 2.

Ipecacuanha, Its Structure and Adulterations.

During the course of the year many specimens are sent to the Microscopical Laboratory for examination. The majority of these specimens are the commercial spices, such as mustard, cinnamon, pepper, etc., and the more common, or the more expensive drugs. Among the drugs sent for examination have been

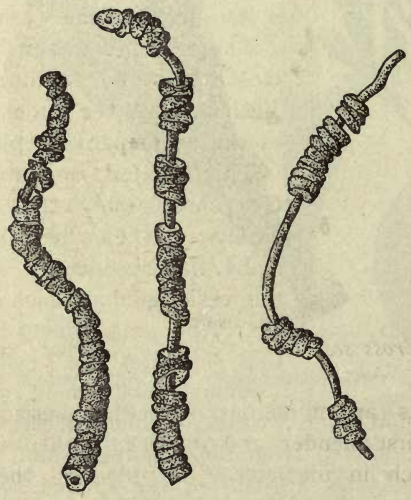


Fig. 1. Roots of Ipecacuanha, natural size.

several specimens of Ipecacuanha. Although this drug is reported by Bentley and Trimen and by Stillé and Maisch as comparatively free from adulterations—frequently having other roots substituted for it—yet the specimens sent here have all been adulterated more or less. Evidently powdered ipecac is losing its reputation for purity and will soon have to be classed

with those drugs and spices commonly reported impure. The substances which were found to be mixed with the ipecac were of the simplest kind and can be detected under the microscope by persons having had no experience in this line of work before. But to understand what belongs to the pure powder one should become acquainted with the physical appearance as well as the structure of the root itself.

The botanical name is *Cephætis ipecacuanha* while the common name is ipecac. It belongs to the natural order Rubiaceæ. It is indigenous to the damp forests of Brazil, New Granada, and the north-eastern portion of Bolivia between about 8° and 22° south latitude. So it is entirely an imported drug.

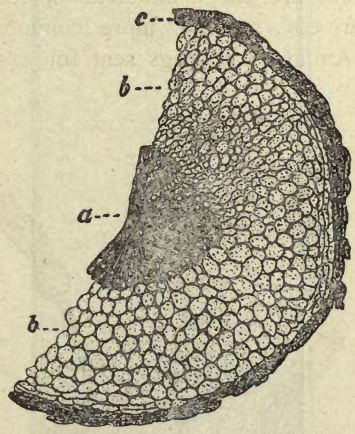


Fig. 2. Cross section of Ipecacuanha root. x 10 diameters.

The roots are numerous, spreading horizontally from their origin. At first slender and white, but when fully grown about 1-5 of an inch in diameter. In preparing the drug for market the smaller roots are discarded, only those of an average thickness being used. They are long, seldom branched, of an orange-brown, or of a dull gray-brown occasionally almost black, irregularly bent and twisted and covered with a very thick bark. There are numerous deep longidutinal furrows running the entire length of the root, transversely marked by ring-like furrows closely packed together. The depressions between the rings being sometimes as deep as the woody cord. These corrugations

frequently number twenty to the inch, and give the appearance of rings strung on a cord, hence the name annulated ipecacuanha, which is applied to this root and by which it is distinguished from the non-officinal ipecacuanhas. The woody cord is about $\frac{1}{20}$

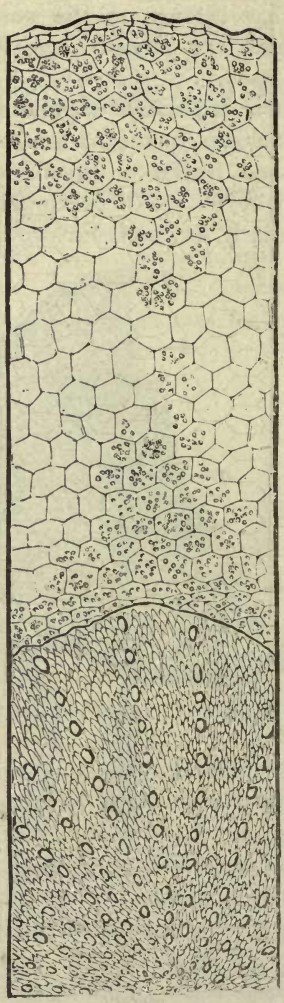


Fig. 3. Cross section of Ipecacuanha root. x 60 diameters.

of an inch in diameter, and when wet shows distinct medullary rays. There is no pith present. The thick bark composes about

three-fourths the bulk and weight of the root, and separates readily from the woody cord.

The roots are collected at all seasons of the year, but prin

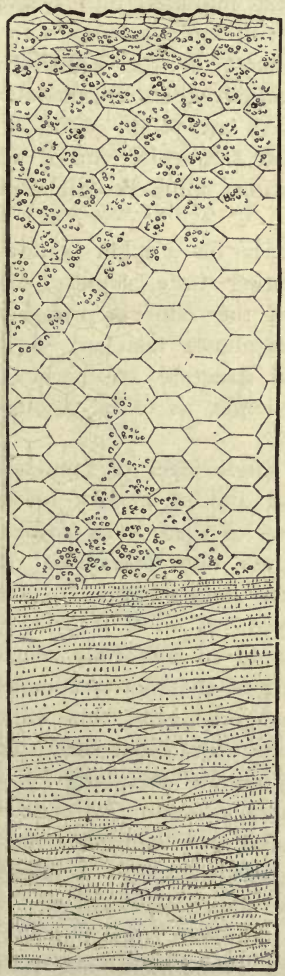


Fig. 4. Longitudinal section of Ipecacuanha root. x 60 diameters.

cipally from January to March. They are dried in the sun and packed in bales. About 15,000 lbs. are brought to the United

States annually. Large quantities of the ipecac of commerce are damaged. They are injured by sea-water and by being gathered during the rainy season. The statement has been made that over four-fifths of the ipecac imported into England is damaged. It is also badly mixed with inferior roots both of the same and of other plants. The most of the substituted roots are nearly smooth, and non-annulated, others are medulated, farinaceous, with white woody cords. All are totally different from the true root. Woody stems are also frequently mixed with the roots. The most of these substitutions under the microscope possess a central pith.

Powdered ipecac is of a light yellow-gray color, with a peculiar bitter, nauseating taste, slightly acrid. It has a faint musty odor; much of the odor is probably lost in the drying process. The wood is almost tasteless.

The microscopical structure of ipecacuanha is so characteristic, although quite simple, as to be a sure means of identification.

There is first a single layer of tabular cells, empty, flattened rather thick walled and of a dark brown color. [Some authors give several rows of these cells and call them cork.* But the best authority gives only one row. It is possible in the preparation for market, the epidermis together with some of the cork cells are destroyed. If so it is a little surprising that only one layer of cells should so uniformly remain.]

The principal part of the root is composed of the bark consisting of oval or hexagonal cells, thin walled, with no intercellular spaces. The cells are loaded with starch granules. These starch grains are very minute averaging $\frac{1}{500}$ of an inch in diameter. They are generally found in clusters of two, three or four, so when separated they will have one or more plane faces with the rest of the grain rounded. A minute depression or dark spot appears near the center of a majority of the grains. These starch grains are so different from the starches of the most of those substances used as adulterations, as to be easily distinguished. Some of the cells of the bark are set apart to contain crystals in the place of starch. These crystals are long and

*Planchon, "Determination des Drogues Simples" vol. 1, p. 498, says "seven or eight rows of cells form the outer cork."

pointed at both extremities, and found in large bundles of from twenty-five to forty lying side by side like Indian arrows. When confined within the cell they are never found crossing or lying at angles. They are crystals of calcium oxalate.

The central part is composed entirely of woody fibre, and medullary rays. The medullary rays consist only of nearly square, thin walled cells loaded with starch. They are much smaller, though resembling the cells of the bark. The woody portion consists of thick walled, short, pointed cells, with pitted walls. They are generally empty and it is the only part of the structure not loaded with starch. There is no pith in the center of true ipecac,

Fig. 5. Potato Starch. x 375.

though there is in the most of the substituted roots. The corticle portion is by far the more active portion of the root. The woody cord being almost inert.

Thinking some of my readers, who have had little or no experience in studying the drugs as they appear in market, so withered and dried, might like to examine ipecac, I will take a moment and help them. A small fair looking piece of the ipecac root should be placed in a dish of cold water for from ten to twenty hours—warm water for a short time will do, though it should not be boiling. Then with a sharp razor a section should be cut across the root just as thin as possible. There is no necessity of cutting the section complete, *i. e.*, having the

whole of the root in the section. Only a very minute piece is needed, that will show both the bark and the woody center. Probably several sections will have to be cut before one will be thin enough. Float this little section on the glass slide with a camel's hair brush. Holding the little piece in its place on the slide with a needle—the needle should have been wedged into a wooden handle for convenience—wash the specimen in water many times with the camel's hair brush, so as to remove as much as possible of the starch. The longitudinal section should be prepared in the same way. In cutting the longitudinal section care should be taken to cut near the center, so as to have some of the woody cord in the specimen. After these sections have been thoroughly examined under the microscope, the powdered ipecac can be studied. A drop of water is placed on the glass slide by means of the camel's hair brush and just a little of the powder taken on the point of the penknife and dusted over the water—only a small amount of the powder is to be taken. After protecting it with the thin glass-cover it is ready to be examined. Any one who has taken these steps, can test for themselves the purity of the powdered ipecac found in the drug stores.

The following substances are reported as having been found in powdered ipecacuanha: almond meal, licorice, corn meal and potato starch.

The presence of almond meal can be detected by the development of hydrocyanic acid upon infusion in water. The presence of the seed coats as well as the central part of the almond may be detected by the microscope. The central part or the cotyledons are composed of thin walled hexagonal cells, smaller than the cells of the bark of the ipecac, and loaded with oil drops. They are entirely free from starch grains. Minute spiral vessels are frequently scattered through these cells. The outer seed coat or the dark brown scurfy part of the almond is made up of large oblong cells, with peculiar pits or dots covering the cell-wall. They are about $\frac{1}{500}$ of an inch broad and nearly twice as long. By the way, if some of these cells are scraped off from the outer surface of the almond and boiled in a solution of caustic soda they will make beautiful objects for examination with polarized light under the microscope. Almond meal is probably not of very common use for mixing with ipecac.

A prominent druggist in one of our western cities told me he had found quite a large per cent. of the powdered ipecac, that was sent to him from the east, to be mixed with powdered licorice. The only way to become acquainted with the appearance of licorice under the microscope is to prepare and examine some of the root in the same way we prepared and examined ipecac root, and then to study some of the powdered licorice. This would hardly be necessary for the identification of licorice when it can so easily be detected by its taste and odor.

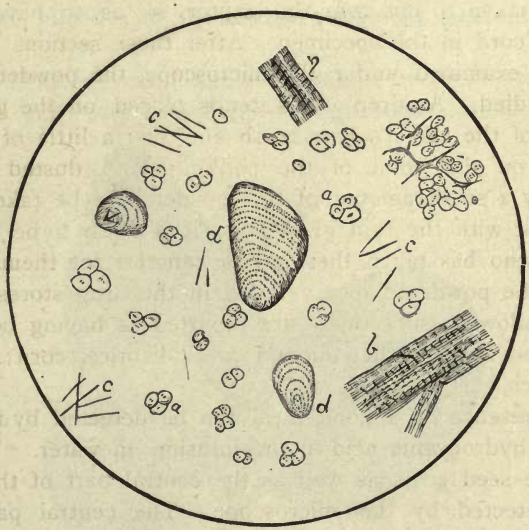


Fig. 6. Powdered Ipecac. a, starch grains of ipecac. b, woody fibre. c, crystals. Adulterated with d, potato starch. x 375

By far the most common substance used is potato starch. Of all the specimens of powdered ipecac which I have examined, every one had more or less of potato starch mixed with it. Only two having corn meal. Potato starch grains are so very characteristic that it would be impossible for any one to mistake them under the microscope for the starch grains of ipecac. In fig. 5 is given an illustration of the starch grains of potato. Large, oval, or irregularly ovate grains. Each one possessing a nucleus

or spot around which is seen numerous rings. Frequently these are as large as $\frac{1}{400}$ of an inch in length. A very simple way for obtaining some of these starch grains for study is to cut into a potato, and the fine white powder adhering to the knife will be the starch, or if a thin slice of the potato be shaved off and placed in a little water in a watch crystal the fine white sediment found at the bottom will be the starch. Fig. 6 illustrates some powdered ipecac adulterated with potato starch.

Boldo Leaves.

THE boldo leaves of commerce are gathered from the shrub or tree, Boldoa fragrans, which belongs to the natural order Monimiaceæ. This tree is a native of Chili, found growing luxuriantly on the hillsides of the central provinces and cultivated in gardens.

It is a tall, evergreen, diœcious shrub or tree, with verdant foliage, fifteen to twenty feet high—though some authors give the

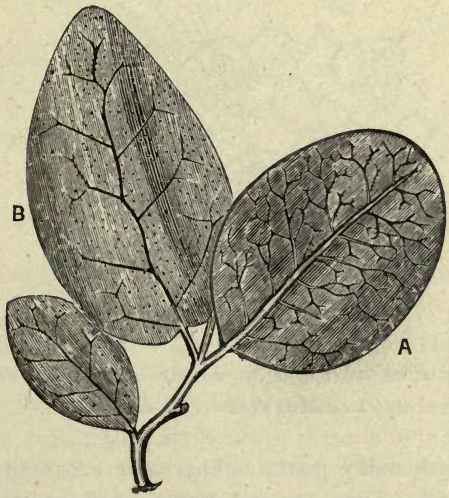


Fig. 1. Boldo Leaves.—A, lower surface. B, upper surface. Natural Size.

height as only from five to six feet. The flowers are sweet-scented and of a greenish-yellow color. The fruit is small, about the size of a pea, sweet, aromatic and of a yellow color, which the natives used as a relish. It is used though in small quantities on account of the sensation of heat left in the mouth and the almost sickening sweetness of the fruit.

The leaves are opposite and borne on short petioles. They are oval, obtuse at both apex and base, coreaceous, strong and rough. The lower surface of the leaf, fig. 1, *a*, is marked by prominent midrib and veins, even the minute net-work of veins showing. The hairs add to the roughness of the lower surface. The upper surface, *b*, is more glossy and is thickly studded with small whitish projections. The dried leaves have a reddish-brown color with a fragrant odor and a refreshing aromatic taste. The lower surface of the leaf, when examined with the microscope, is found to be composed of the usual epidermal cells, see *a*, fig. 2, quite uniform in size and appearance, while the stomates *b*, are like those of other leaves. Each stomate, however, is surrounded by four epidermal cells. The hairs found on the under side of the leaf are not very numerous or uniform in size or appearance. They are multicellular

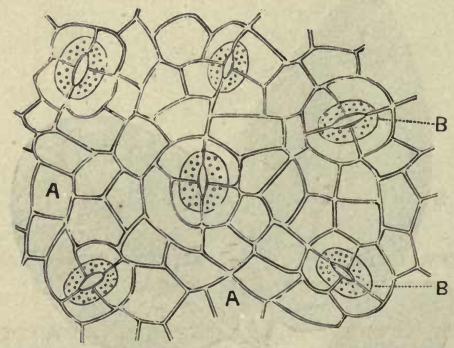


Fig. 2. Lower Epidermis and Stomates.—a, Epidermal Cells. b, Stomates. Magnified 350 Diameters.

and stellate with many points. The same are seen in fig. 3 more highly magnified. They are not borne on a pedicle or stem, but directly from the lower epidermis, as seen at *a*, fig. 4. The hairs found on the upper surface of the leaf are unicellular, long, slender, and borne on an enlarged multicellular base, formed only of epidermal cells. These hairs are so easily brushed off the leaf that in the commercial leaf the projections are generally found without the accompanying hairs.

Fig. 4 represents a cross section of the leaf, showing the relations of the projections and hairs to the rest of the leaf. One can

easily see here that the roughness of the upper surface is due only to the enlarged bases of the epidermal hairs. The portion of this

Fig. 3. Epidermal Hairs.—From the Lower Surface of the Leaf. Magnified 200 Diameters.

section seen at *c* was more highly magnified and represented in fig. 5. The upper surface of the leaf is furnished with two rows of thick walled epidermal cells, which is unusual, as leaves have generally only one row. Directly beneath these is found the usual row of elongated palisade cells, *b*, filled with chlorophyll. In a dried

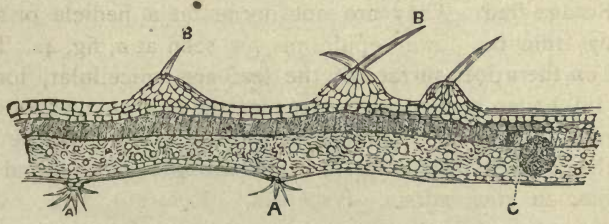


Fig. 4. Cross Section of Leaf.—a, Stellate Hairs on the Lower Surface. b, Unicellular Hairs on the Upper Surface. Magnified.

specimen the chlorophyll is of a yellowish-brown color. Forming the central part of the leaf are the loosely packed cells, called parenchyma, loaded with brown coloring matter and dead protoplasm. The lower surface of the leaf is protected by a single row of thick-walled epidermal cells, similar to those of the upper surface. Numerous large glands *e* are found scattered through the loose parenchyma. In some of these are pendant cystoliths, *d*, others contain the essential properties of the boldo leaf, as boldina, tannin, and aromatic resinous compounds. There are smaller oil cells,

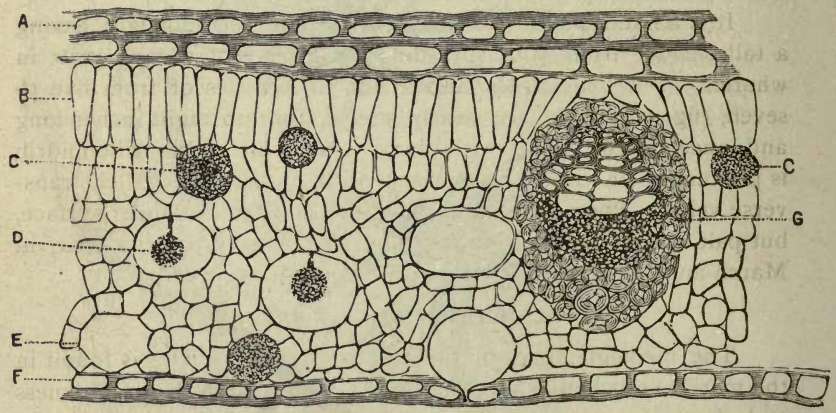


Fig. 5. Cross Section of Leaf.—a, Upper Epidermis. b, Palisade Cells. c, Oil Cells. d, Cystoliths. e, Glands. f, Lower Epidermis. g, Vascular Bundle. Magnified 350 Diameters.

c, scattered through the leaf, sometimes found even between the palisade cells and the upper epidermis ; these are loaded with essential oil. At *g* is seen a cross section of one of the veins of the leaf.

Boldoa fragrans is recognized by both the French and the Germans as officinal.

Travelers inform us that it has been used by the natives of Chili from time immemorial. In 1870 the medical men of Chili first began to use it in their practice. Shortly after it was introduced into the United States. It is now recommended for use in liver troubles, in rheumatism, dyspepsia, ulceration, etc., while it is receiving some notice as a curative agent in yellow fever.

ALSTONIA SCHOLARIS.

ALSTONIA SCHOLARIS is found in India, in the tropical islands and in Northern Africa.

It is a handsome forest tree from 50 to 80 feet in height, having a tall slender trunk with spreading branches that always grow in whorles. The leaves are also found in whorles of from five to seven, (fig. 1). They are nearly sessile, four to eight inches long and lanceolate or oblong with bluntly acuminate ends. The midrib is prominent on the lower surface, with numerous parallel, transverse veins. They are of a bright green color on the upper surface, but pale and dull on the lower. The tree flowers twice a year, in March and December.

DESCRIPTION OF THE BARK.

The medicinal part of the tree is the bark. This is found in the market in irregular pieces from ⅛ to ½ an inch in thickness and of a spongy texture. The external surface is rough and uneven and of a grayish-brown color, with numerous cream-colored patches that flake off like scales. The inner surface is mealy in consistency, and of a bright yellow color. It is of no particular odor, and its taste is purely bitter, neither aromatic nor acid.

MICROSCOPICAL STRUCTURE.

The outer layer of the bark is composed of from eight to twenty rows of tabular parenchyma. The cells are thick walled and empty (see *a*, fig. 3). The cellulose of the walls is colored a deep amber. As a dividing line between this structure and the next, that is, between the outer and middle layers of the bark, is found a delicate texture, consisting of three or four rows of clear white empty cells (*d*, fig. 3). This outer layer is called the cortical layer by some authors.

The middle layer of the bark, which is the principal part of the whole specimen in bulk (*b*, figs. 2 and 3), is composed of loosely

packed oval cells, with masses of enormous, bright yellow stone cells, scattered thickly through the layer (fig. 3, *e*). They are so numerous as to be seen with the naked eye, and they give the mottled appearance to the outer part of this layer of the bark. These stone cells (or *sclerenchyma*) are much smaller toward the

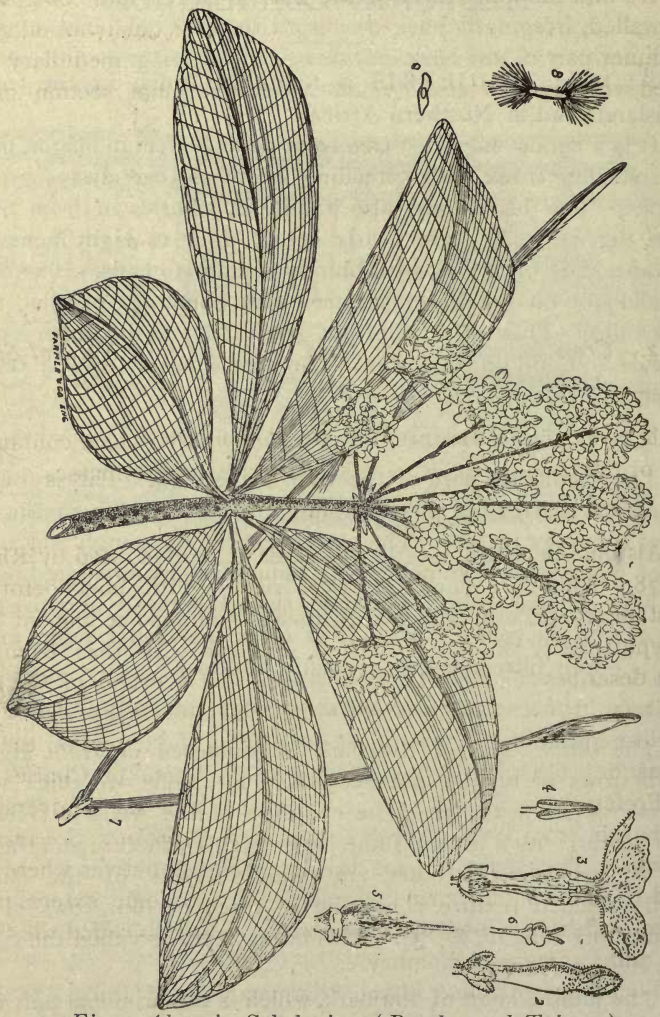


Fig. 1. Alstonia Scholaris. (*Bentley and Trimen.*)

inner bark, though they do not disappear entirely. Many of the cells of the middle bark contain beautiful crystals of calcium oxalate. Found much more numerous toward the outer edge (*f*, fig. 3). Some of the cells are enlarged and filled with oil or the essential properties of the plant.

We find the inner layer of the bark is narrow and composed of thin walled, irregularly packed cells, with occasionally an oil gland. The inner part of the bark is traversed by waving medullary rays, loaded with minute starch grains. A longitudinal section of the

Fig. 2. Cross Section of Dita Bark. Three times its Natural Size.—a, Outer Bark. b, Middle Bark. c, Inner Bark.

middle layer gives a few large laticiferous vessels, which contain the latex or the concrete juice of the tree—in brownish masses.

HISTORY.

Alstonia Scholaris was first described and illustrated by Rheede in 1678. Although its praises were sung by the poets before the Christian era, according to Dr. Rice, who found some ancient Sanskrit epic poetry on the subject of Alstonia. In 1841 Rumphius again describes the tree and gives the probable origin of the name *Scholaris*. It seems the school children used to make slates from the close-grained wood of this tree, making the letters on the slab with sand. The plant is named Alstonia in honor of Charles Alston, Professor of Botany and Materia Medica in the University of Edinburgh from 1740–1760. It was named *Echites Scholaris* by Linnæus. The common name among the island natives where it is found is *Satween*. In the Philippines and to some extent in the United States, it is known as Dita Bark. It is also called the "devil tree" and Palimara of Bombay.

The drug is officinal in the Pharmacopœia of India. It is not employed to any extent in Europe, and is not recognized in either

the British Pharmacopœia, or in the U. S. Dispensatory. Descriptions are given of it, however, in Bentley and Trimen's Medical Plants, No. 173; in Flückiger and Hanbury's Pharmacographia, page 421 (new edition), and in the National Dispensatory, page 140.

There is a large tree of Alstonia Scholaris growing now in the royal gardens of Kew.

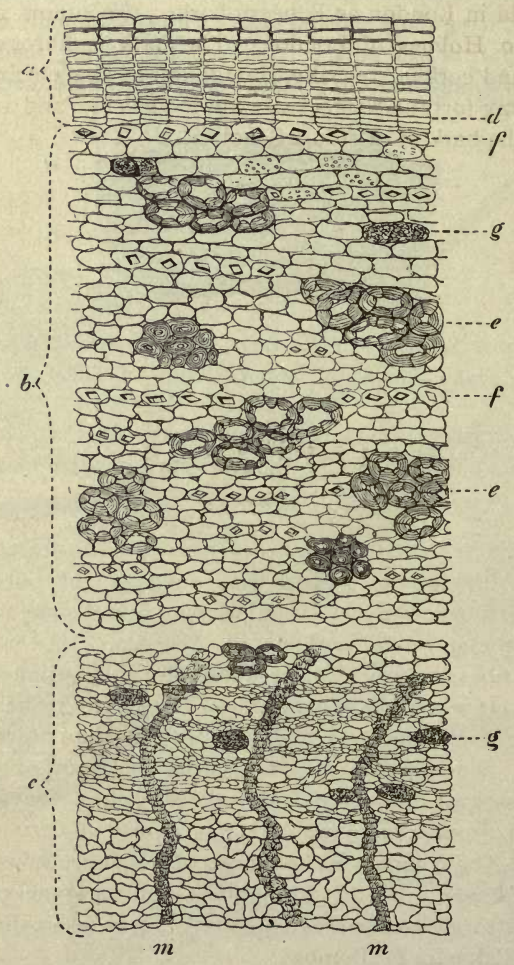


Fig. 3. Cross Section of Dita Bark.—a, Outer Bark. b, Middle Bark. c, Inner Bark. f, Crystalls. e, Stone Cells. g, Oil Glands. m, Medullary Rays. x70 diameters.

It possesses strong tonic and antiperiodic properties, and is ardently recommended by many as a substitute for quinine.

ALSTONIA CONSTRICTA.

Closely related to this drug is Alstonia Constricta, called the Australian fever-bark. It is occasionally imported from India, and has been sold in London as Bebeeru bark. It contains no alkaloid, according to Holmes of London. The bark is fibrous internally and rough and corky externally, though all of the specimens which it has been my fortune to meet are more delicate and of a lighter color than the bark of Alstonia Scholaris.

FOLIA CAROBÆ---JACARANDA CAROBA.

THE Caroba leaves of commerce are obtained from a native tree of Brazil. It belongs to the family Bignoniaceæ, and has been honored with a number of names. The correct one probably is Jacaranda Caroba, given it by De Candolle ; although the name Jacaranda Procera, given by Sprengel, is in quite common use.

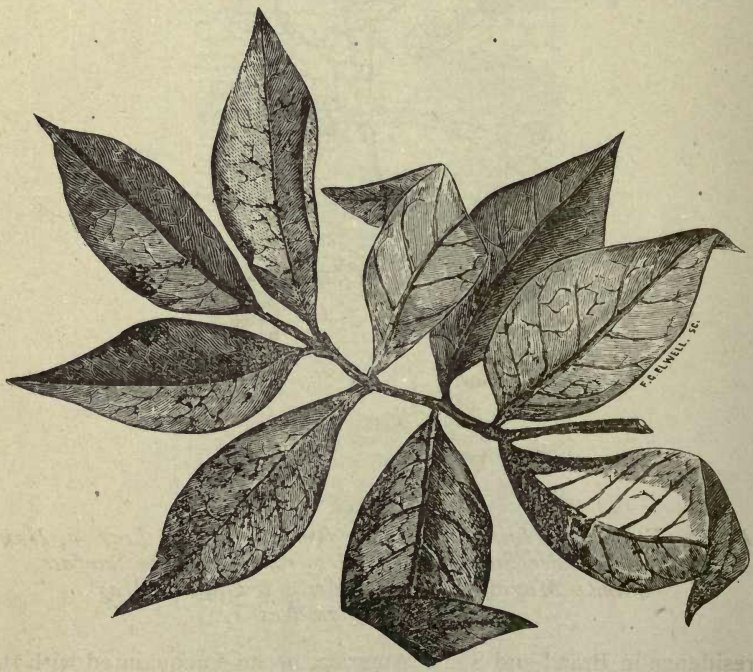


Fig. 1. Jacaranda Caroba. One Branch of a Compound Leaf. A Pinna or Leaflet. Natural Size.

Martins called the tree Cybistas Antisyphilitica, and Vellos gives it the appropriate title of Bignonia Caroba.

The medicinal properties of the tree are found principally in the leaves, and their beneficial effects have been known for a long time to the native doctors of the aborigines of Brazil, and it has been used extensively by the Brazilian physicians. John Alves de Canerio, an eminent physician, submitted it to the Academy of Medicine at Paris, and from this introduction it was described in the Materia Medica. Mr. Camillo Weber, a licensed apothecary of Leipzig, Rio de Janeiro and Montevideo, during his sixteen years

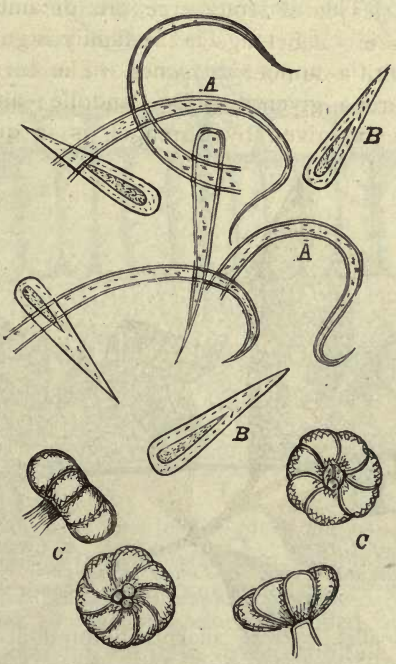


Fig. 2. Epidermal Hairs and Glands from the Caroba Leaf. a, Hairs from the Under Surface. b, Hairs from the Upper Surface. a and b Magnified 100 diameters. c, Glands. Magnified 500 diameters.

residence in Brazil and South America, became acquainted with the extensive use which the resident physicians made of the Caroba leaf. By his recommendation it was introduced into Hamburg by J. Von der Heide, apothecary.*

*Dr. Ottoker Alt. Hamburg,—in the Pharmaceutical Zeitung, Bunzlau, Berlin.

The tree grows to a height of from 30 to 40 feet. The root is externally of a dark red, internally of a yellowish white color. The flowers are red and white in showy terminal cymes, and they have an agreeable honey-like flavor; the fruit is a woody bivalved capsule, containing several winged seeds. The stems are considerably branched and produce large compound leaves. The beautiful dark green leaves are bipinatified, being divided into from six to eight pinnæ, while each pinnæ is divided into from eight to twelve pinnules or leaflets. The illustration represents only one branch or pinna of the leaf (see fig. 1). The leaflets toward the end of the pinna are seen on the upper side, while the under side shows in the

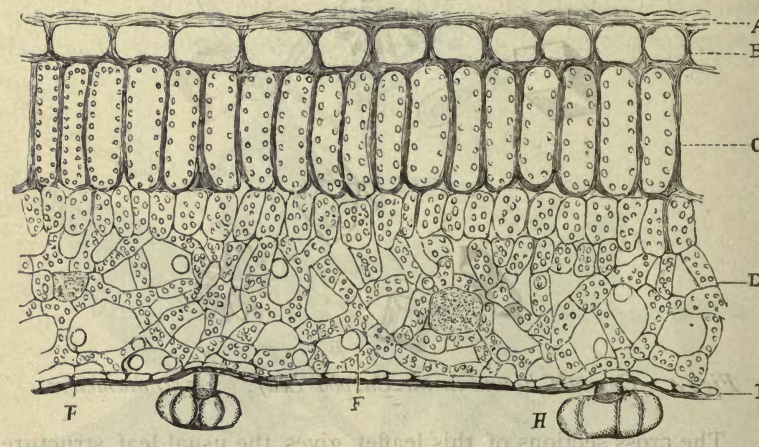


Fig. 3. Leaflet of Carobа. Cross Section. a, Cuticle. b, Epidermal Cells. c, Palisade Cells. e, Lower Epidermis. f, Oil Drops. h, Epidermal Glands. x 500 diameters.

others. Each leaflet is oval, sharply pointed at the apex and the base, and with a smooth border. The upper surface of the commercial leaflet is dark brown and smooth, while the lower surface is much lighter in color, and with strongly marked midrib and veins; and is wooly on close inspection. The wooliness is caused by the presence of numerous long, slender and empty hairs (see *a*, fig. 2). The hairs are of an unusual length and thickly covered with minute projections of cellulose.

There are only a few hairs found on the upper surface of the leaf. They are much shorter, broader and only faintly marked with projections. (See *b*, fig. 2.)

There are in addition to these hairs some beautiful glands thickly scattered over the leaf surface (see *c*, fig. 2). These are wheel-shaped, and composed of eight or ten cells. In the dried leaf they are of a reddish brown color, and probably contain oil and some of the essential properties of the leaf. Similar glands are found on the surface of a few other kinds of leaves, and they generally contain "secreted resinous, gummy or other substances."*

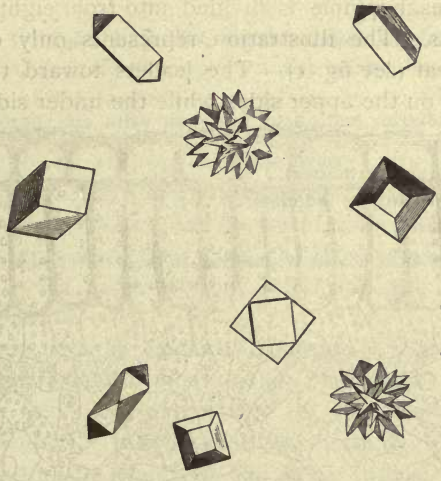


Fig. 4. Crystals Found in the Caroba Leaf. x 750 diameters.

The cross sections of this leaflet gives the usual leaf structure (see fig. 3). A thick cuticle protects the leaf on the upper surface (*a*). The epidermal cells (*b*) are unusually large. Directly beneath these are the long slender palisade cells, filled, when fresh, with bright green chlorophyll; but in its dried condition filled only with dead brown chlorophyll bodies. The lower half of the leaf is composed of the usual loosely packed parenchyma (*d*) with occasionally drops of oil and grayish colored, granular masses. The lower epidermis (*e*) is much more delicate, while the cells are either collapsed or are smaller, and the cuticle is thinner than the corresponding parts on the upper surface of the leaf. Two of the large epidermal glands (*h*) are yet attached to the lower epidermis.

A chemical examination of the leaf has been made, with the

*See Bessy's Botany, p. 96.

following results.* In 1,000 grammes of air-dried leaves there were contained:

Carobina	1 620
Crystallic carobic acid	0.040
Crystallic carobic, sebacylic acid	1.000
Carobon (balsamic resin)	26.666
Neutral resin—not perceptible to taste or smell	33.334
Chlorophyll and vegetable wax	9.000
Extractive matter	10.550
Extractive matter, tartaric, lactic and oxalic acids	10.000
Malic acid and calcium	0.200
Tannic acid	4.390
Albumen, dextrin, malic acid, inorganic salts, etc., fibrine and water	885 010
Balsam (extractive matter)	14 420
Substance resembling humus	0.890
Bitter substance	2.880

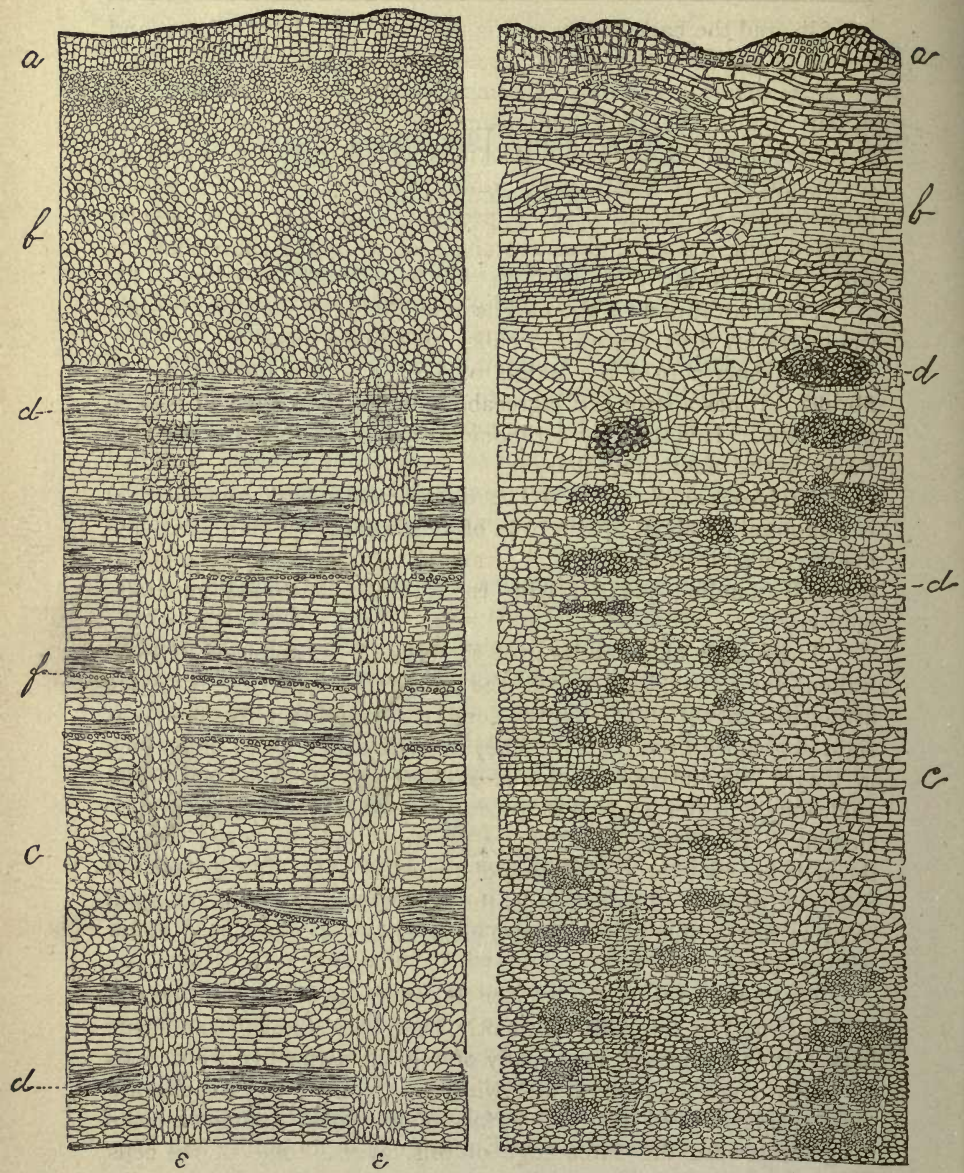
*This report was given by Charles W. Zaremba, M. D., in the Therapeutic Gazette of February, 1880, p. 34.

JAMAICA DOGWOOD--PISCIDIA ERYTHRINA.

FOR a long time all that was known regarding this plant, was the fact that the natives employed the bark of the root for taking fish in some of the larger rivers; hence its name piscidia erythrina—from piscis, a fish. A certain quantity of the powdered bark of the root would be thrown into the water with the certainty of stupefying or narcotizing a large number of the fish. These would float on the top of the water, and so were easily caught. It killed the smaller fish and sometimes even the larger ones. Fish caught in this manner were eaten without hesitation and were not considered unwholesome.

The common name is Jamaica Dogwood; at one time it was called Linné Erythrina Piscipula—the "fish-catching coral-tree," and it has been sold quite extensively in Brazil under the name of mulungû or murungû. It belongs to the natural order Leguminoseæ. It is found in the islands of the West Indies, and is indigenous in the Antilles, where it is extensively distributed, flourishing chiefly in the lowlands, and on calcareous and volcanic soil in the vicinity of the coast. It is found most frequently in Jamaica. It is a small tree, of about twenty feet in height, of very irregular spreading branches, with long compound leaves. The leaflets are opposite, three or four paired, with an odd one. They are oblong or elliptical, rounded at the base, entire, somewhat coriaceous, about two inches long and quite pointed. When young the leaves are covered on both surfaces with minute hairs, but when old they are nearly smooth. The lower surface is paler than the upper, and covered with minute white dots. The leaves are shed early in the year, and previous to the development of the new foliage the flowers make their appearance. The wood is considered valuable, being very heavy, and resembling our English oak in durability and firmness.

The pulverized bark of the root is the part employed in catch-



Jamaica Dogwood. A, Longitudinal Section. B, Cross Section. a, Outer Bark or Cork. b, Middle Bark, or green layer. c, Inner Bark, or liber layer. d, Liber Bundles. e, Medullary Rays. f, Crystals. x 37 diameters.

ing fish, and the bark of the root is the part used in medicine, and should be gathered during inflorescence, otherwise it is unreliable.

Description.—The bark of commerce appears in pieces of two to four inches in length, and from one to two inches wide, and about an eighth of an inch in thickness. The outer surface of some of the pieces is of a dark grey brown, while others are of a yellow brown with no shade of grey present. The bark is frequently studded with flattened protruberances of a lighter color than the surrounding cork.

The central part of the bark is much lighter colored, and when wet or freshly broken is of a peculiar blue-green color.

The inner part of the bark is of a dark brown color and very fibrous. It has a strong, disagreeable odor of opium when broken into pieces. It is strongly acrimonious and produces a burning sensation in the mouth and pharynx.

Microscopical Structure.—The cork or outer bark (see fig. 1, *a*) is composed of about fifteen rows of thin-walled, regular, parenchymatous cells, brick shaped, and arranged radially, *i. e.*, the length of the cell standing parallel with the radius. They are generally empty.

The middle or green layer of the bark (*b*) is composed of thin-walled, long, oval cells. In the longitudinal section they are arranged tangentially, *i. e.*, the longest diameter of the cell is at right angles with the radius. They average about 1-250 of an inch in length, and about one-fourth as wide, containing clear white chlorophyll bodies and dead protoplasm and chlorophyll. Occasionally a crystal is found as if by accident. In the cross section the cells are oval or round and of irregular sizes. Sometimes oil cells are present. The cell walls themselves seem to have absorbed coloring matter, for they are not a clear white as is usually the case with cellulose.

The inner layer of the bark or the liber layer (*c*) constitutes the principal part of the bark, frequently being four-fifths of the whole bark. It is composed principally of regular parenchymatous cells of nearly equal diameters, and with thin walls. These cells are quite regular toward the inner surface of the bark, and grow more irregular toward the outer edge of this layer. Some of the cells show pitted marks, which are deposits of cellulose on the cell walls.

Bundles of liber fibre are arranged in concentric rings through

this part of the bark, hence its name liber layer. On a cross section (see fig. 1, B) these fibres are composed of hexagonal cells with very thick walls, having only a spot or a central line for an opening. On a longitudinal section the fibres are frequently 1-10 of an inch in length. These long cells of the liber fibre give the fibrous structure to the inside of the bark. On either side of the bundles of liber fibre are rows of polyhedral crystals of calcium oxalate.

Medullary rays, composed of regular brick-shaped cells similar to those of the cork, are seen travesing this layer. This part of the bark contains, besides the liber and crystals of calcium oxalate, some oil ducts and resin glands,—apparently different in no respect from the surrounding cells,—some small scattered laticiferous tissue and separate oil drops.

Physiological Action.—It is said to be a "cerebro-spinal drug, expending its influence almost entirely upon the nervous system. It causes at first an increased activity of the cerebrum. This is shortly followed by a dazed feeling. There is a violent itching pain in the upper portion of the medulla oblongata, with nervous trembling."

It causes burning soreness in the eyes and heat in the internal structure. The eyes look wild and staring and there is a constant movement. There is excoriation in the nares posteriores with sneezing and coryza. There is also an aching pain in the temples. It induces labored breathing, and gradually the whole body comes under its influence. There is an intense excitation of the nervous system, causing a hot flush over the entire body, the pulse is increased ten or fifteen pulsations, with pain in the heart and restlessness, which, however, is quickly succeeded by obliviousness.*

"Experiments upon animals have demonstrated the power of this drug in large doses, to produce prompt paralysis of the motor nerves, while it does not affect the great centers of innervation—cerebellum and medulla,—the great sympathetic nerve or the smooth or non-striated muscular fibre, neither does it affect the seat of intelligence, the heart rhythm, the temperature, or the peristaltic action."†

Properties and Uses.—Dr. William Hamilton, of England, speaks of this plant as a powerful narcotic, capable of producing sleep and relieving pain in an extraordinary manner.

*George William Winterburn, M. D.
†Prof. Fernando Altamarano, M. D., of Mexico.

"In Brazil it has an established reputation as a nervous sedative. Its action seems to be over the nervous centers; it causes sleep without producing the cerebral hyperæmia, nausea and nervous disturbances, which succeed opium and morphia. The sleep is tranquil and refreshing; it soothes bronchial cough and moderates the paroxysm of asthma and nervous coughs."‡

The active principle is a resinoid, soluble only in strong alcohol.

The dose is from 30 drops to two fluidrachms. It is applied externally as well as given internally.

Its most valuable therapeutic use is assuaging nervous pain and producing sleep.

‡C. H. Hanson. M. D.

USTILAGO MAIDIS.

THE question of the substitution of what is known as corn ergot for that of rye, is one of some interest just at present, on account of the cheapness and ease with which the corn ergot can be obtained. It is not properly called corn ergot, for it does not belong to the same family as the rye ergot—*claviceps purpurea*, and is like

Fig. 1.

rye ergot only in its action. It is nothing but the smut which destroys such large quantities of corn, and is known scientifically as *Ustilago Maidis*. Its substitution for *claviceps purpurea* is something

quite recent, and so has very little history. It is not recognized by the U. S. Pharmacopœia.

It is found as a smut growing on almost all parts of corn. The stem, the leaf, the flower, the fruit alike are troubled with this plague. It seems to prefer for its host only tall, healthy plants, and everywhere it takes the most spacious room for its accommodation. It first attacks the summit of the plant or the anthers, and then gradually spreads until the whole plant above the ground is affected. It has never been found in the ovary or the walls of the ovary of the pistillate flower, or in the staminate flower of the Zea Mays ; but it is found in every other part of the plant. (See Ann. des Sci. Nat. Vol. VII, Ser. III, page 85.) As soon as the fruit is attacked the

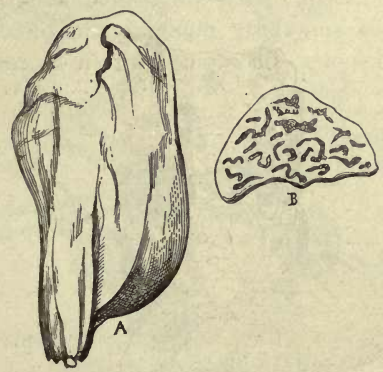


Fig. 2.

outer wall begins to swell out in a most wonderful and grotesque manner, sometimes the affected kernel will change from its natural size to that of the fist. It occasionally turns to a deep red, and if broken gives out a sooty fluid having a somewhat bloody appearance. As it grows older this mass looks like a finely pulverized black soot, with the parenchyma and the vascular woody fibres yet present in the powder.

Fig. 1 represents an ear of Indian corn affected with *Ustilago Maidis*. The disease has affected the whole ear in such a way that it can never develope into healthy fruit. The little bracts on the affected part are tumified by the presence of the smut, and are developed in the most abnormal shapes. The whole outer surface is

covered with openings or blotches, where the spores have broken through, and the outside very much darkened by their presence. Almost every one is so well acquainted with the appearance and growth of this smut that it is not necessary to enter at any length into the details.

Fig. 2 represents one of the bracts alone, with a cross section of the same, showing how the internal structure of the bract is changed from its normal appearance, and is packed full of the fine spore dust.

In fig. 3 we have the spores of the Ustilago Maidis; they are almost as light as the air, and can be carried for a great distance by the wind, the whole outer surface of the spore is covered with minute spines or thorns; they are of a dark-brown color, nearly opaque, and have a singularly pungent and offensive odor. The protoplasm of the spores is contained within a central cell or sack;

Fig. 3. 900 Diameters.

each spore has two surrounding membranes, the inner thin and nearly transparent, while the outer is dark-brown and roughened. At *b* we see a filament or little root just developing from one of the spores. This delicate root works its way into the tissue of the stem, leaf or some part of the corn, and continues to grow until a perfect net-work of roots is made; then after some intermediate steps there develops the great mass of spores which constitute the so-called corn ergot. On account of their extremely thick walls, it is hard to check or destroy this disease.

When *Ustilago Maidis* appears in its natural condition in commerce, it is a mixture of almost everything pertaining to blighted corn, corn smut, powdered corn leaves, etc., even frequently containing the powdered cob. When the greater part of the coarse

material is taken out and the remaining fine powder examined, we find, besides the great quantities of spores, specimens showing the minute structure from almost every part of the corn, and even of many of the neighboring plants.

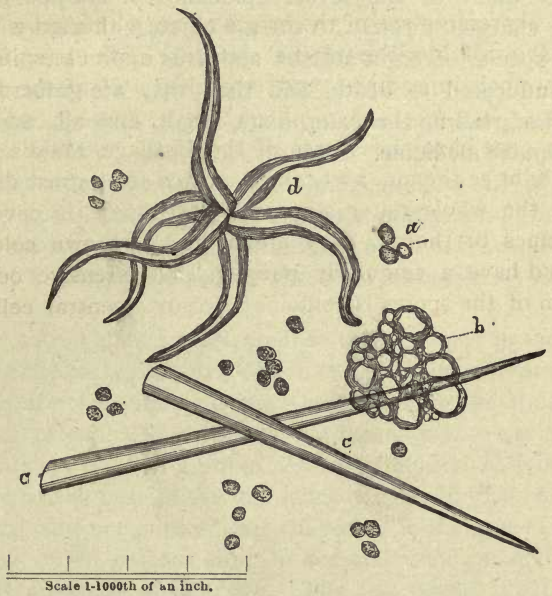


Fig. 5. Commercial Ustilago Maidis. x 250.

In fig. 5 we have a representation of the fine powder as it is sold in the drug stores. There are found in this powder many things that do not belong to Ustilago Maidis. The characteristic spores (*a*) are found in great quantities everywhere. The long slender hairs seen at *c* are the minute hairs found on the surface of corn leaves, and which give the roughness to the leaf; they are commonly present in the powder. At *b* is seen a fragment of the woody part of corn, or more properly speaking, a cross section of a vascular bundle. At *d* we see a stellate hair which is quite characteristic of some of the weeds growing along the road-side and in the fields. Very frequently we find the spores of other parasites mixed with the ergot, such as rust from wheat, onion smut, blight on fruit trees, etc.

Ustilago Maidis is not only destructive to corn, but dangerous to the animals that live on the corn so affected. The death of animals has been traced directly to corn stalks badly affected with smut, and it is said that mules, fed upon corn thus diseased, lose their hoofs. Some of the severe epidemics of Europe and Asia have been charged directly to the use of corn affected with Ustilago. One species of ergot attacks and lives upon caterpillars until they are suffocated to death, and then they are gathered by the Chinese, who grind up the caterpillars, ergot and all, and deal it out as a popular medicine.

Commercial Fibres.

COTTON consists of the down or fine cellular hairs attached to the seeds of plants belonging to the genus *Gossypium* and to the natural order *Malvaceæ*. It is indigenous to all of the inter-tropical regions. These plants supply the raw material for one of our greatest industries, and for the clothing of all nations, and certainly may claim a recognition among the most valuable of nature's production.

The cotton plants cultivated in the new and in the old world constitute the two great divisions in the commercial cottons, and are known as the Oriental and the Occidental, or the Indian and the American cottons. The seeds of the Indian cotton are never black and are always covered more or less with epidermal hairs, and the curvature at the base of the leaf lobes is compounded of two opposite curves, and not purely heart-shaped as in the case of the American plant. "The cottons most in demand among manufacturers of the world, are those of America. The Sea Island plant in the soft maritime climate of the low-lying islands off the coast of Georgia, where frost is scarcely known, has surpassed all other descriptions of cotton in the strength, length and beauty of its staple."*

The stalks of the cotton plant are made to answer some valuable purposes. Besides being used for thatch and basket, a fibre is obtained that can be converted into various kinds of cloth, equal to those manufactured from jute. Thus we have a kind of linen goods made from the cotton plant. Paper is manufactured from the stalk and leaf of the plant.

Cotton hairs are woven into a very great variety of fabrics, more than is imagined by the most of persons; for about two thousand different samples of cotton goods have been reported.

Cotton hairs are readily distinguished under the microscope from any other of the fibres. They are long, several times longer than the

*Isaac Watts, Chairman of the Cotton Supply Association, Manchester, Eng.

diameter of the field—unicellular, flat, but with thickened edges, so that frequently one would say the sides of the fibre were concave rather than flat, always with more or less of a twisted appearance. The fibres of cotton, having only a single layer of cellulose for their cell walls, are easily collapsed. While the cells of linen and of all kinds of fibre consisting of a liber structure are cylindrical or nearly so. When cotton hairs are growing they are full of protoplasm; as soon as they become ripe, however, the protoplasm is absorbed and the thin delicate walls, unable longer to retain their youth and fullness, become wrinkled and collapsed, looking very much like a twisted bit of old ribbon. Any one can see how the cotton hairs look when they are ripe and ready to be gathered, before they have reached the manufacturers' hands, by examining the cotton from our common cotton batting, or by examining the hairs on the surface of the leaf in the white foliage plant called "dusty miller."

Linen comes from the inner part of the bark of the Flax plant *Linum*, and is cellular in structure. There is a central opening running the entire length of the fibre. It sometimes is not possible to see it all the way without treating the fibre with some reagent to bring it out. The cell walls are much thickened by secondary deposits and are tougher than ordinary wood fibre. The firm consistency of the walls keeps the fibres full and round so that linen is never found collapsed like cotton. Occasionally the cells are pointed but generally the ends are square. Sometimes the cells are of nearly the same length as their breadth, though generally much longer. The secondary deposits on the cell wall are quite uneven, so that some cells have a much larger central cavity than others, and occasionally a cell wall will be exceedingly thickened. These layers of cellulose peel off in strips, giving a rough appearance to the surface. When boiled in potasic hydrate or treated with the stronger acids faint spiral markings appear on the cell walls. Jute, flax and hemp are very similar, though coarser than linen.

The individual cells of jute are rather longer than those of linen. Generally of a greyish-brown color, appearing like dead cellulose. Quite a prominent central cavity with smooth edges is present, seeming to be perfectly empty. Much more uniform than in linen. It is apt to break straight across when broken at the ends of the cells, but breaks with a long fibrous fracture if broken anywhere in the middle of the cell.

The fibres of silk are long, slender and rod-like, with occasionally one having a flattened side. When broken the ends separate with a straight or a smooth fracture. They are solid, having very much the appearance of glass rods, no cells, no central opening, no structure whatever. Averaging 1-1600 of an inch in diameter, though some are even 1-800 of an inch in diameter. Their average size is the smallest of the commercial fibres. They have a clear, white color when unstained, and are semi-transparent, and highly refractive.

Wool fibres are either cylindrical or oval. The surface of the fibre is covered by minute cells, lying one upon another like shingles on a roof, or like scales on a fish, though each scale is bordered by a waving line. The value of wool for felting depends on the proportion and size of these epidermal cells or scales. Wool fibres are remarkable for their softness, flexibility and wavyness. These cells are most beautifully seen in white hairs that have been thoroughly soaked in oil of turpentine, and mounted in Canada balsam. Soaking wool fibres in a solution of soda will separate the epidermal cells or scales from the rest of the fibre. Hairs of some animals polarize light. An interesting object of this kind may be made by placing two series of white hairs of a horse in Canada balsam so as to cross each other at an angle and viewing them by polarized light.

The fibres of cotton and linen are not affected by water, alcohol, ether, benzol or any weak solution of the acids or the alkalies, not even when raised to the boiling point. But strong solutions of either acids or alkalies, when applied with gentle heat, will slowly destroy the fibres.

A simple test is the brilliancy of the coloring matter taken by the different fibres, for the aniline dyes give a strong permanent color to silk and wool, while in cotton it is merely surface color and easily washed out.

If you are called upon to examine a piece of dress goods, or any material in which the presence of foreign fibre is suspected, take a small piece of the goods and boil it for a few minutes in a solution of soda (ten parts of soda to ninety parts of water). It dissolves the silk or wool fibres and leaves the cotton or linen unaffected. It is possible to estimate very nearly the proportion of the mixture of the animal and the vegetable fibres, by filtering carefully the residue and comparing with the known amount taken. If the

alkaline filtrate be treated with the acetate of lead the silk will give a white precipitate and the wool a black precipitate.

Wool contains a certain amount of sulphur—silk being entirely free from it. This gives us another means of detection. In a solution of plumbate of soda, wool becomes black while silk is not affected.

NOTE. For illustrations see lithograph plate at end of Part I.

PART III.

PART III.

SOME HINTS ON THE PREPARATION AND MOUNTING OF MICROSCOPIC OBJECTS.

The following articles, written by W. H. Walmsley, of Philadelphia, are reprinted from "The Microscope."

I.

SO MUCH has been written and published on this well worn subject, that it would seem almost superfluous, if not presumptuous, in me to attempt to add thereto. But recollections of the many failures in my early attempts in years long since gone by, of the wastage of time and materials incurred, and the unsatisfactory knowledge gleaned from books, impel me to jot down for the benefit of others, the results of actual experience in this work.

Whilst by no means asserting that the processes to be described are *the best*, I would say that I have found them to be uniformly satisfactory, yielding always the best desired results, and that all have stood the tests of actual use and experience. I shall give nothing that I do not use in my daily work; and shall not state what "my friend Smith" *says* "is his process," or that "I am told Mr. Jones does this and that." Smith's and Jones' processes *may* be vastly superior to those I shall give, but not having tested, I shall not speak of them, my intention being to give simply and succinctly as possible, my methods of preparing and mounting ordinary objects of interest, which may prove of use to many a beginner in this fascinating pursuit.

Fig. 1. Dissecting Needle.

Nearly all microscopic preparations are mounted in one of three ways: in balsam or other resinous media; in air in the dry way, and in aqueous or other fluids. Of these methods I shall proceed to spesk first of balsam mounts, the *essential* materials for which work are as follows:

A bottle or tube of pure filtered Canada balsam; a bottle each of 95° alcohol, pure benzole, oil of cloves, and liquor potassæ (the latter with glass stopper); a pair of fine *curved* forceps, which should be nickel-plated; another of fine dissecting scissors, and a small dis-

secting knife; two needles in handles; a few small red sable brushes; one large camel's hair brush; a glass pomatum jar; nest of porcelain dishes, and a few watch glasses; a wide-mouth 8 oz. vial, with glass stopper; small glass rod; some pieces of very fine brass wire; glass slips and covers, with suitable labels; and a small bell-glass.

To these may be added the following *non-essential*, but very convenient articles: A capped bottle, with glass rod, for containing the balsam (see figure 7); a small brass table with spirit lamp; a turn table; porcelain mounting plate (hereafter to be described);

Fig. 2. Curved Forceps.

magnifying glass on stand, with elongating arm; white zinc cement, shellac cement, and colored fluid for ornamental ringing; a bottle of absolute alcohol; and a writing diamond. The *luxuries* may be mentioned under the head of a well made self-centering turn table; a hot water drying oven; find spring scissors; an assortment of dissecting needles, hooks, scissors and knives; and a pair of binocular magnifiers, mounted upon a firm stand, with focusing adjustment. But all the processes of mounting to be here named may be performed with the tools and materials mentioned under the head of *essentials.*

Fig. 3. Small Dissecting Knife.

Having thus started in business with our capital of tools and materials, let us proceed to put them to the test of actual use. And I can provide no better subject for a beginning than a common blow fly, or an ordinary house fly, either of which will afford material for several different processes of balsam mounting. A female should be selected, as the ovipositor, which usually contains some eggs, affords a most interesting and beautiful object.

Vivisection not being favored by the writer—first kill your fly in the most humane manner possible (chloroform is recommended); —then proceed to clip the wings off close to the body, which, not needing any preparation, may at once be placed in alcohol, in

one of the covered porcelain saucers. The legs, being cut off, should be placed in liquor potassæ, which should be contained in the glass pomatum jar with a cover. By gently pressing the abdomen, the ovipositor will protrude to its full length, and should then be cut off close to the body, and also placed in the liquor potassæ. The tongue should be pressed out in like manner, and when found (under the magnifying glass) to protrude to the full extent, with all

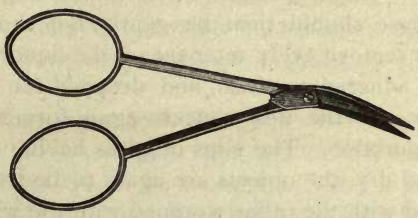


Fig. 4. Dissecting Scissors.

its parts, should in like manner be cut off and follow the legs and ovipositor. Then the abdomen may be cut open with the scissors, the viscera washed out with the small sable brushes and water, and the skin or epidermis containing the spiracles be placed in the liquor potassæ. The trachea and eyes, requiring different treatment to that we are now pursuing, will not be followed further at present.

The length of time necessary for the various parts to remain in the liquor potassæ, varies materially. Thus an hour, or at the most, two, will suffice for the tongue and ovipositor, whereas the legs and epidermis will require an immersion of not less than one or two days. Great care should be taken to remove them before too much color is abstracted, as the beauty of a preparation is quite lost if it be pale and colorless. A good rule is to remove these parts from the liquor as soon as they assume a lightish brown appearance; placing them in water, and carefully washing and brushing them with the sable brushes. One of the nest saucers will be found a most convenient vessel for doing this in. They should then be transferred to a glass slip, taking care (with the tongue) so to spread it out with the needles as to show the lobes and false trachea, and (with the feet), to show the hairy pads. When properly spread out, place another glass slip over them so that they are pressed flat between the two, and wrap tightly with a piece of fine brass wire,

which for this purpose should be cut in lengths of 10 or 12 inches. The wire is recommended, rather than thread of any kind, because there are no fibres to become entangled with the specimen, and thus mar its beauty; and it may be used many times over. The slips thus wrapped should then be dropped into a vessel of water, and left for some hours. On being taken from the water and the wire removed, the slips should again be placed in a saucer or small plate of water, and carefully separated to avoid marring or injuring the specimens. These should then be gently, but thoroughly washed and brushed, to remove every remnant of the liquor potassæ or dirt that may have adhered to them, and dropped for a few moments into alcohol; one of the nest saucers again forming a convenient vessel for this purpose. The slips of glass having meanwhile been wiped clean and dry, the objects are again to be transferred to one of them, covered with the other, wrapped with the wire and dropped into alcohol, which for this purpose should be contained in the wide mouthed bottle with glass stopper. And here they may safely rest until we are nearly ready for the final operation of mounting; be it the next day, or year, matters not, as the alcohol will not alter or bleach them.

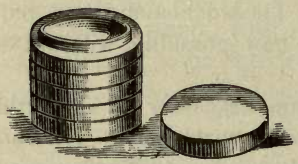


Fig. 5. Porcelain Saucers.

The final work to be done upon our specimens, preparatory to mounting, is transferring from the alcohol to oil of cloves, which is a substantial repetition of the previous transfer from water to alcohol. The slips of glass taken from the bottle, and the wire removed, are to be placed in a saucer containing alcohol, and gently separated, to avoid injury to the specimens, which are now to receive their final brushing. If we have provided ourselves with absolute alcohol, a short immersion in the same, in a watch glass is advantageous, but not absolutely necessary. And now having poured a small quantity of pure oil of cloves into one of the porcelain nest saucers, we carefully transfer the tongue, feet, etc., to the same, not forgetting the wings, (which all this time have lain quietly in

the alcohol, as originally placed, not having needed any of these complicated manipulations), immediately replacing the cover to exclude dust.

It will be observed that I rigorously exclude turpentine in all forms from my work. I have ever found it a most unsatisfatory medium, foul smelling, sticky, and rendering all tissues immersed in it stiff and brittle. Oil of cloves, on the contrary, is in all respects a most admirable medium, rendering all tissues and substances fully as clear as turpentine; is agreeable to the sense of smell, does not stiffen anything immersed in it, and is perfectly miscible with balsam or damar.

After this digression, and whilst our specimens are clearing up in the oil, let us see to our glass slips and covers, and to the balsam in which the former are to be mounted. Very many processes for cleaning the slips and covers have been given to the world by various writers, and probably they are all good. I give only my own, which I have used for many years, with entire satisfaction, and therefore can confidently recommend it. The slips (which should be smooth edged), are placed in a basin with *hot* water and good soap, and wiped dry with a soft towel, after being thoroughly washed and rinsed. They are then placed in a drawer, and are ready for use at any future time, merely requiring to be brushed off with the large camel's hair pencil when used. The thin covers (which should *always* be circles, and not squares, as making neater and more readily finished mounts), are dropped one by one in a glass tumbler, containing sulphuric acid, and allowed to remain there for some hours. The acid is then poured off, and water *carefully* added, which in its turn is decanted and replaced with fresh water, the whole contents of the glass being freely agitated until every trace of the acid is removed. One of the glass pomatum jars is now to be partially filled with alcohol, and the thin covers placed therein to remain until wanted for use, when they can be removed with the forceps, and a slight wiping with an old, soft linen handkerchief will leave them brilliantly clean.

Fig. 6. Mounting table with lamp.

My own preference is for absolutely pure filtered balsam as af-

fording the most satisfactory results in all sorts of mounts, but that from which the spirits of turpentine has been expelled by heat, and replaced by chloroform or pure benzole, answers a most excellent purpose, whilst the many damar mediums are also good. But following the plan upon which this article was begun, of giving only those processes, which I habitually practice, and know to be satisfactory, I shall confine myself to pure balsam alone. The great secret in its successful use is to have it of just the proper consistency, neither hard enough to resist the thrusting of a fly's wing into a drop of it when placed upon the slide, or so limpid as to spread and run when so placed. If too thick, a little chloroform carefully stirred into the bottle containing the balsam, will reduce it to proper consistency; if too thin, a covering of cotton cloth should be placed over the mouth to exclude dust, and the bottle put in a warm place for a day or two. My own plan is to put it—when found just right—into collapsible tubes, from which the proper amount can be squeezed out upon the slide, and in which it will remain of the same consistency until the last drop is used; but most persons will prefer to dip it from a wide mouthed bottle with a small glass rod, and to such I would strongly recommend the capped bottle, which I have named under the head of *non-essentials*, as it excludes all dust, allows the rod to remain in the balsam when not in use, and prevents any foreign particles from falling into the latter, as must be the case in all bottles closed with a cork.

Fig. 7. Capped Bottle for Balsam.

And now we have brought our work down almost to the final operation. Our specimens are soaking in oil of cloves waiting to be mounted, our glass is clean and bright, our balsam in its bottle, our forceps and needles lying in their places ready for instant use. What more do we need? Only a lamp or other convenient method close at hand for warming the slide and cover; and some mode of *centering* the object before applying the cover. The latter *may* be done by laying a slide on a sheet of white paper or card board, and

drawing its outline with a pencil, and on removing the slide making a mark exactly in the centre of this drawing. Of course, when the slide is replaced, this mark will apparently be in *its* centre, and thus the balsam and object can be accurately placed in proper position. The principal objection to this method, is that the slide is apt to slip out of place, and thus to render accurate centering almost impossible. A most admirable contrivance for this purpose, however, is the "porcelain mounting plate," named under the head of *non-essentials*. This is made of a photographic porcelain plate, 3 x 5 inches, ground flat upon one side, on which are cemented at right angles to each other, two small strips of glass, the one three inches in length, and the other one inch. A mark is then made upon the plate with a pencil, exactly 1½ inches from one strip, and ½ an inch from the other, so that when the ordinary glass slip is placed upon the plate, with one end in contact with the two strips, this mark is seen exactly in the centre. The slip is held firmly in place, and the white surface of the plate serves admirably as a background upon which to arrange the object.

Fig. 8. Collapsible tube containing mounting material.

At last we seem to be really done with all our preliminary work, and ready for mounting. But wait another moment. Though as before stated, the oil of cloves is perfectly miscible with the balsam, and a specimen may be transferred directly from the one to the other, it is a very slow drier, and an object so mounted might be months in hardening sufficiently to handle, even if the utmost precaution be taken to drain off all the superfluous oil. Fortunately we have an excellent remedy for this trouble close at hand. Pouring a small quantity of benzole, into a watch glass, we place in it one of the specimens, say a wing, and immediately cover it with the small bell glass to exclude dust, and prevent the evaporation of the benzole, which is exceedingly volatile. And now at last we are ready for the mounting.

One of the cleaned slips having been placed upon the mounting plate, and its surface dusted off with the brush, a drop of balsam of exactly the proper dimensions, is to be placed in its centre, indicated by the mark upon the plate. And here, practice alone must be our guide, for the amount must be varied according to the

diameter of the covering glass and the thickness of the object. In mounting our present specimens, say with covers of ⅝ inch diameter, it will be found that more of the balsam will be required to fill up evenly to the edge of the cover, with one of the legs than with a wing. The great aim should be to get exactly the right amount dropped on the slide at first, so that it will fill to the edge of the cover when the latter is pressed down, without any excess exuding, or any additional filling being required. No rule can be given for doing this; only continuous practice can give one the necessary skill ; but it is worth trying for, since a mount thus made possesses an artistic appearance, which cannot be equalled by any

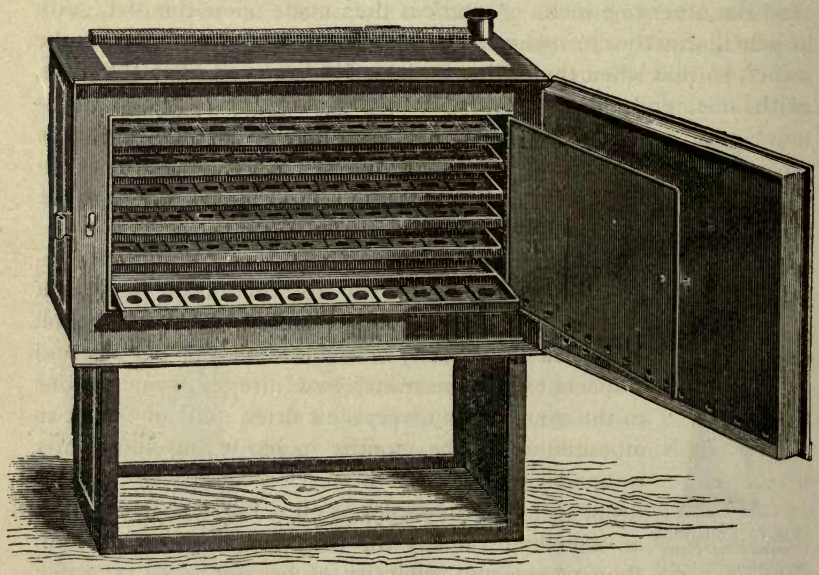


Fig. 9. Drying Oven.

other means. The drop of balsam having been placed in the centre of the slide, the wing is taken from the benzole with the forceps, and thrust into it—the balsam—gently, but firmly ; and then with one of the needles it is to be pushed down upon the slide, (into firm contact with its surface, in fact), and arranged in proper position. Now mark this point carefully. If the object be left suspended in the drop of balsam, as soon as the covering glass is applied, it will float out of position, and much valuable

time, and more patience be consumed in getting it back, together with the added risk of destroying it in the attempt. But if it be placed in close contact with the surface of the slide, it will become firmly fixed. The forceps having been wiped clean (it is still better to have a second and heavier pair for this purpose), one of the cleansed covers is taken up by them, slighly warmed over the lamp, and gently laid upon the balsam, which will spread out under its warmth, if the operation be successfully performed, as the cover settles down to its level. This can be aided by carefully warming the slide over the lamp, holding it in a perfectly level position, and the warming should be continued until the fluid balsam has reached the edge of the cover all around, when the slide should be set aside in a moderately warm place for say 24 hours. On no account should the cover be touched or pressed down at this time, and no notice should be taken of any bubbles that may appear, as they will move out to the edges and depart of their own accord. On the following day the slide may be again very gently warmed, and the cover very slightly pressed down with the forceps, after which, if we possess the luxury of a drying oven (see figure 9), we will place it therein, and by the aid of a small kerosene lamp, maintain a temperature of about 120° Fahrenheit for a week or ten days, when the preparation may be taken out to remain, we trust, "a thing of beauty and a joy forever."

The same process that we have followed to its end with the wing, suffices for all the other portions of our fly, and indeed, for all specimens not thick enough to require a cell; for these special directions will be given in a future article.

If our work has been entirely successful, the slide is now finished, with the exception of labeling. But if (as is more likely), there was an excess of balsam, which has exuded from beneath the cover, it must be cleaned off with a knife, and being by this time hard and resinous, this is very readily done, after which a little soap and water will remove all traces of it. Most persons will prefer to finish their slides with a ring of cement, and for this purpose a turn-table, which I have enumerated among the *non-essentials* for balsam mounts, must be provided. The slide having been accurately centered, a ring of the shellac cement is to be applied, followed by successive ones of white zinc, until the space between the surfaces of the slide and covering glass is quite filled up, care being

taken to allow each coat to harden before applying a fresh one, which is rapidly accomplished with this invaluable cement. A narrow ring of some bright color makes a pleasing finish, and can be readily made by adding to the ordinary damar medium a sufficient quantity of any desired color, ground in a little oil. All these cements should be applied by small *red sable* brushes, and the best mode of using them is to have the bottles in which they are contained, filled with long, tapering corks, into the under side of which the brushes are to be fastened. They are thus always immersed in the cement when not in use, and never can become stiff and dry; whilst they undergo no apparent deterioration. I am now using in my white zinc bottle the same brush that I placed there six years ago, during which time it has been employed to ring many thousands of slides, and is now as "good as new." The long cork forms a very convenient handle for the brush, and if care be taken to wipe it and the neck of the bottle with alcohol, occasionally, they will never stick together.

It is to be noted that the flattening between glass slips, etc., is only necessary in the case of objects of considerable thickness, such as the fly's leg we have been preparing. All *thin* objects, as sections of animal or vegetable tissues, etc., may be carried through the alcohol and subsequent stages, in the same manner as that pursued with the fly's wing; or, if perfectly *dry*, may be at once immersed in the oil of cloves, or even mounted in the balsam, without previous soaking in anything.

And now, having brought our balsam mounts to a successful completion, I must also make an ending of the present paper. In future ones (if this be well received), I propose to give some practical hints on mounting in the dry way, both opaque and transparent objects suited to that method of preparation; also on fluid mounts of various sorts, and possibly others on the double staining of vegetable tissues.

Should any of my readers desire to see a balsam mount prepared according to the foregoing directions, I shall be pleased to exchange with him or her for any well prepared original slide.

II.

OUR first chapter of practical hints having been mainly devoted to balsam mountings, it was the writer's intention in the next, (if ever written,) to give other methods. But on carefully reviewing the former I find that directions have been given for mounting only very thin or flattened substances, with which but a small amount of balsam is needed between the slide and cover, and the latter lies parallel to the former, with but little inclination to tilt up on one side. There are, however, many objects, so thick as to require some sort of a cell to contain the large amount of balsam, necessary to cover them, and to prevent the excess from running out beneath the cover upon the slide; whilst other subjects are so delicate that the mere weight of the thinnest covering glass, pressing upon them, would crush them out of all shape. We will, therefore, with the reader's permission, give some hints as to various methods of doing this before proceeding with other branches of our subject.

Undoubtedly the most perfect cell, that has yet been devised, is one of glass. For very shallow cells, to be used in mounting diatoms, nothing can equal those cut from thin covering glass, such as are used exclusively by Möller, in mounting his Typen- and Probe-Platten ; and slides of arranged diatoms. These are cemented to the slides by a thin layer of balsam, heated to such a point, as to expel all, or nearly all of the turpentine; and nothing can excel the neatness and perfection of their appearance and finish, whilst they are, of course, quite permanent.

Where deeper cells are required, those cut from glass tubes of various diameters and shapes, or drilled from slips of different thicknesses, and cemented to the slides with Marine Glue, are to be highly recommended, as they are extremely neat in appearance, and entirely permanent in character. The objections to all glass cells, are the difficulty of preparing them by ordinary workers, and their extreme costliness, if purchased ready made. If the latter consideration, however, be of no moment to the reader, I would say by all means use them, and nothing else, as they never give any trouble, and are always neat and handsome in appearance.

Block-tin makes a very good cell, which may be attached to the slide by Marine Glue the same as glass, and which will contain fluid balsam quite as well; but they must either be purchased of the dealers, or made with a special and expensive punch. They are

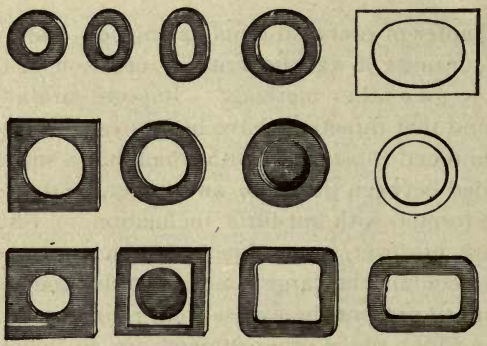


Fig. 10. Cells.

more difficult to finish neatly than those of glass, and are only recommended by reason of their comparative cheapness. Brass curtain rings *may* be substituted for them, and if carefully handled in the mounting, may be found permanent and satisfactory; but my own experience has not been favorable toward the latter, either as to convenience of handling, permanency, or neatness of appearance.

Fortunately we have a material, admirably adapted to making cells, which any one can readily do for himself and at a trifling cost. It is the ordinary white sheet wax used in artificial flowers and which can be procured in three thicknesses, known as "ordinary," "double thick," and "pond lily." A punch specially constructed for cutting cells from these sheets, can be purchased from the opticians at the small cost of a dollar and a half; and enough to mount a dozen or more slides may be punched in a few moments.

FIG. 11.
WAX CELL PUNCH.

A turn table is necessary for attaching these cells to the slides, and some form of a self-centering one is recommended; the enhanced first cost, being the only reason for hesitancy in making a choice. A simple form of *centering—not self*-centering, mind you—

devised by myself many years since, in my early microscopical days, and which costs but a fraction more than the simplest turn table without it, has been found so satisfactory in my own work, as well as that of many friends who have adopted it, that I am led to describe it here and to give an illustration as well. Indeed, the latter shows the simple device so well that further description is almost useless. A sheet of thin brass with a stop at the left hand end, precisely one and a half inches from the centre, is attached to the surface of the whirling table by a small milled head; by which the distance of the edge of the brass plate from the table's centre may be varied more than half an inch. A slide precisely 3 x 1 inches, having been accurately centered on the table by means of the concentric rings turned about the centre of the latter, — and held in position by the usual spring clips, — the guide plate is moved up until the lower left hand corner of the slide rests securely in the angle formed by the upper edge of the guide and the stop at its left; when the milled head is screwed up tight and the centering arrangement is ready to do its allotted work. It follows that any rectangular slide 3 x 1 inches, slipped under the spring clips and into the angle of the guide, must have *its* centre exactly over that of

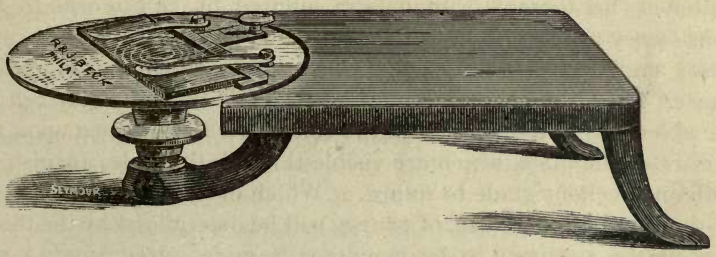


Fig. 12. Turn Table.

the table, and a ring of cement once run upon it when so placed, can be followed by as many more as are desirable, by simply replacing the slide in the same angle, without any trouble in adjusting. Since, however, very few slides are absolutely rectangular or have exactly parallel edges, it will be found convenient in practice, to

Fig. 13. Writing Diamond.

place a mark upon the left hand end of each before running the *first* layer of cement thereon, after which it may be replaced as often as desired, without loss of time. A writing diamond is the most convenient tool for doing this with, but a small scrap of paper pasted upon the slide will answer every practical purpose. The surface of the table should be sharply scratched at the angle formed by the guide-plate, so that in the event of having to move the latter to accommodate a slide not originally ringed by it, the centering adjustment may be returned to its original position in a moment and with absolute accuracy. My original device was cut from a piece of stiff card board, and secured to the table by means of the screws which attached the two spring clips to the latter; and this primitive affair did excellent service for many a long year, ere it gave way to my present truly *self*-centering instrument.

Let us take breath, for we have been a long while getting our turn table; but that invaluable instrument secured, at last we are ready for business. Taking a clean slide from our store box of the same, we slip it beneath the clips of the table, and bring it to a centre at once, if we have followed the foregoing directions. First dusting its surface carefully with a camel's hair brush, we proceed to trace a flattened ring thereon, with balsam, diluted by chloroform to the consistency of *city* cream, using a small red sable brush for the purpose; ample directions for doing which were given in the preceeding paper. The size of this ring must be the same as that of the cell we are about to place upon it, and the concentric lines turned upon the surface of the table, which are visible through the slide, furnish us with an excellent guide to follow. Which of the three thicknesses of sheet wax we shall use, of course, will be determined by the thickness of the specimen to be mounted: if none, (used singly,) will furnish a cell sufficiently deep we must add one or more rings of the wax, taking care to coat each thoroughly with the balsam before adding the next ring. This may be all done, without removing the slide from the turn table, and thus a symmetrical and accurately centered cell may be built up in a very few minutes; and if necessary, may be at once filled with balsam and specimen, and the mounting completed. It is better, however, to set it aside for a day or two, (in a dust-tight case,) for hardening. And now, having completed our cell, be it of glass, metal or wax, let us proceed to mount

our specimen therein, without a legacy of air bubbles, or vacuoles; which is a very easy matter to do—when you once know how.

Suppose that our first specimen is a lot of Foraminiferous shells of considerable size, which will require a cell of the depth, made by a ring cut from a single thickness of pond lily wax. Choosing such an one from our stock of already prepared cells,—hold the slide very carefully over the lamp, until it feels sensibly warm to the touch, then immediately fill the cell with pure limpid balsam, just sufficiently to reach the upper surface of same all around and to form a slight convexity from side to side. The balsam may be squeezed from a collapsible tube, or lifted from the supply bottle by means of a glass rod, at pleasure; my own preference being decidedly for the former method, as being cleaner, more convenient, and keeping the balsam entirely free from dust, or evaporation. Now gently warm the slide again to the same degree as before and with a clean needle, — well heated over the lamp,—explore the inner edges of the cell down to its glass bottom, so that if there be any vagrant air bubbles imprisoned thereabouts they may be freed, float to the surface and disappear of their own volition, or at the touch of a hot needle point. A careful examination of the cell's contents should be made with a pocket lens, as a further surety that no imprisoned bubbles are left therein. And it may be well to remark here and for all the past as well as future operations, that they should be conducted speedily as possible, since the balsam begins to harden as soon as brought into contact with the air, rendering it more and more difficult to manipulate, the longer the operation lasts. The bell glass should also be close at hand to place over the slide during any pause in the work, to exclude dust.

The small shells, —previously freed from all moisture or dust —may now be carefully dropped into the cell and moved into position with a warm, *not hot* needle, until the desired amount is deposited therein. Examine again to make sure no fugitive air bubbles are left; and now we are ready for the covering in. The glass circle for this purpose should be slightly smaller than the wax ring which forms the cell: thus, if the diameter of the latter be ¾ of an inch, the former should be $\frac{11}{16}$. The covers can be purchased in all sizes, one-sixteenth of an inch apart, from ¼ to 1 inch in diameter.

Taking up the cleaned circle with the forceps and slightly warming it over the lamp, we proceed to apply it to the cell precisely

in the same manner as previously described for a balsam mount, in which no cell was employed; care being taken to let it fall gently so as to drive out the excess of balsam over the edge of the cell, and so down on to the surface of the slide, without moving the shells out of their positions or leaving any *vacuole* within the cell. Should the latter mishap occur, the only remedy is to push the cover off to one side and apply sufficient fresh balsam to fill the vacancy: replacing the cover in position by a gentle sliding motion. This necessity, however, is to be avoided by all means, if possible, since it makes a "*smeary*" job, very difficult to clean off nicely afterward. Should any small air bubbles yet remain, after all our precautions, they need cause no annoyance or thought, as they will disappear of themselves, as do those remaining in mounts made without cells. The excess of balsam that flows over on the slide during the placing of the cover and closing of the cell, should be roughly wiped off with a wisp of tissue paper, so as to leave but a thin layer for the final cleaning, when the mount is hard and complete. Also at this time the cover should be carefully adjusted with the needles or forceps, so as to rest concentrically upon the surface of the cell, equally distant all around its circumference from the *outer* edge of the latter; and should be firmly pressed down upon the cell; and over the same. The cover, however, must never be pressed in its centre, or over the balsam. Being elastic, it readily bends downward under such pressure, driving out a portion of the balsam, over the edge of the cell: the pressure being removed, the glass returns to its former level, drawing in *air* to replace the expelled balsam, and thus compelling us to do our work all over again. The slide should now be set aside in a warm but not hot place, and allowed to thoroughly harden, when the superfluous balsam may be scraped off with a dull knife blade, and the final cleaning made with a rag moistened with benzole, or better—chloroform; after which soap and water will restore the pristine polish of the glass. The *finish* must be left to the taste of the worker. If all the proceedings, thus far, have been neatly and carefully executed, the slide will present an exceedingly neat appearance, without any ring of cement being run upon the edges of the cell, but it will look still better if finished with white zinc cement, and a narrow ring of color, as described in my first paper, care being taken to coat the edge of the cover, first, with shellac, or some other cement, which is insoluble in balsam or benzole.

These directions for mounting in balsam with cells of varying depths, and made of sheet wax, are identically the same as though we were using those of glass, metal or other substances. Further, if our specimen, (instead of being dry, as were the supposed Foraminifera,) has been carried through the preliminary stages of alcohol and oil of cloves, it may be transferred directly from the latter, or from benzole, care being taken merely to drain off all superfluity of either, and to avoid air bubbles in the immersion. Whole insects, large as blow flies, may be thus mounted, without flattening or alteration in shape. Directions for so doing and for rendering them sufficiently transparent may be given in a future paper.

Even the simple wax cell may be beyond the immediate reach of many workers, who may still find a necessity for employing some substitute to prevent the crushing of a delicate object; or to hold the cover parallel over a specimen too thick for the ordinary mode of balsam mounting. For such, the following very simple contrivance can be made to answer a most useful purpose, and at the same time make a very neat appearance. Prepare a number of slips of paper and card-board of various thicknesses, by gumming upon one side. They may be placed in a convenient box for use when required. Selecting a slip slightly thicker than the object we desire to mount, we will proceed to cut four minute squares from it; then placing a cleansed slide upon our mounting plate will stick these squares thereon, at equal distances from the centre. These distances will, of course, be regulated by the size of our object and the diameter of the covering glass, as the latter must cover all the squares when laid in position. The gum is to be moistened, of course, to attach the squares to the slide, and when they are in proper position, the whole must be warmed sufficiently to drive off *all* moisture, which would otherwise cause a milky appearance in the balsam. A drop of the latter having been placed in the centre of the slide and the specimen properly arranged therein, a cover is to be warmed and placed upon it according to former directions, pressing the same down gently with the forceps until it rests equally upon all four of the squares of paper or card-board. Should the object be decentered during this operation, it may be pushed back into position by a flattened needle introduced between the slide and the cover. This useful little tool can be readily made by drawing the temper from a large needle and hammering it out flat upon an anvil or any smooth

hard surface of iron or steel; after which one end may be inserted into a match by way of handle. The needle should always be warmed over the lamp before thrusting it beneath the covering glass, to avoid the formation of air bubbles. If the balsam first applied be insufficient to fill out perfectly to the edges of the cover, more may be added by means of the glass rod. It will flow under the cover by capillary attraction and fill up evenly all around, if the operation be carefully performed. Then come the final operations of setting away to harden (always in a flat position), and the ringing with cement, or not, as the worker's fancy dictates. A mount made in this manner is very simple and easy, requires no outlay for even the materials for the cell, and can be made quite neat and handsome in appearance, as this faithful reproduction of one will testify to the reader's eye.

The mounting of diatoms in balsam is probably familiar to all of my readers, and yet, I feel impelled to give a few hints on this branch, albeit at the risk of telling what every one already knows full well. I do not propose to touch upon the cleaning of these at present, but presuming all this preparatory work to have been already well done, I will briefly tell how to mount them in an easy and expeditious way.

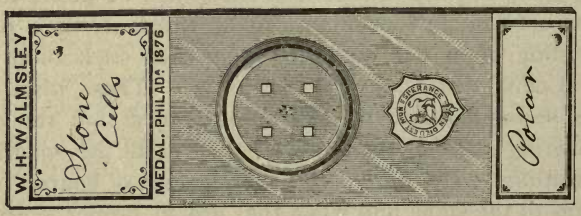


Fig. 14. Specimen.

For this purpose we shall require, in addition to the tools and materials already mentioned, a glass tube about six inches long with a bore of say $\frac{3}{16}$ of an inch, a homœopathic vial, or still better one made from glass tubing, of the form shown in illustration, and a brass table, larger and heavier than that shown in our first paper, with spirit lamp. Having these ready, with the cleaned diatoms in the stock bottle, and our balsam, (pure), slips, circular covers, and mounting plate, let us proceed to work. Shake the stock bottle carefully until its contents are evenly distributed throughout, then with the glass tube take up two or three dips and transfer to the

small vial, which fill with distilled or pure filtered water, and allow the diatoms to settle to the bottom, when the fluid must be carefully poured off, and the vial again filled with water. The object of this is to get rid of almost every trace of the alcohol, which contained the diatoms in the stock bottle, and which, if not removed, would prevent them from being evenly distributed over the covers. I say *covers*, for diatoms should always be mounted upon these, and not upon the slides. Now place upon the table as many covers as you desire to mount, separated some little distance from each other, and with the glass tube drop a portion of the contents of the small vial of diatoms in water upon each. The vial should be gently shaken between each dip, to distribute the diatoms evenly, and the amount of fluid placed on each cover should be sufficient to extend to the edge, and assume a convex form over it. The diatoms will distribute themselves evenly over the whole surface, care being taken not to disturb them by any jarring of the table. The dip is to be made from the vial by thrusting the tube down nearly to the bottom and closing the top with the forefinger: the contents are deposited upon each cover, by gently raising the finger and allowing the air to enter. A little practice is necessary to perform this successfully always. Our covers now being all ready, with watery burden covering the tiny diatoms, we light our spirit lamp and carefully apply its flame beneath the table, moving it back and forth and occasionally withdrawing it altogether, our object being to slowly evaporate the water, without causing it to boil or in any way disturb the diatoms. As soon as the evaporation is complete, the lamp may be left untouched and the table heated to the highest degree possible, in order to insure a thorough drying of the diatoms, which are now ready for the final mounting.

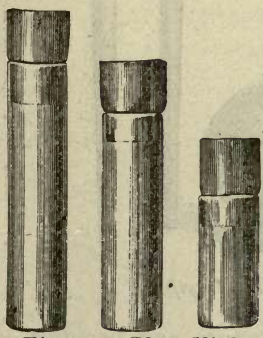


Fig. 15. Glass Vials.

Place a slide upon the mounting plate and a minute drop of *pure* balsam in its centre, and grasping one of the hot covers with the forceps, turn it over upon the balsam, which will quickly spread out to its edges, and the mounting is complete: done as quickly as I can tell of it. If desired, the slide may be heated over the lamp until all the turpentine is driven off, when, upon cooling, the cover

will be found firmly fixed; but the preferable way is to set it aside for hardening in the usual manner. The smallest possible quantity of balsam should be used, and no ringing or other finish is necessary.

And now, having given hints as to various modes of making balsam mounts, I must bring this second installment of my talks to an end; having reached the limit of my space, without touching upon any other methods of mounting, as was my intention, and which must be left to another time.

It might be inferred, from the length at which I have dwelt upon balsam and its uses, that I held it in supreme regard as a mounting medium. But such is by no means the case. Whilst it is invaluable as a preservative—and mountings made in it are probably nearer to being absolutely *permanent* than any other — it possesses many defects, which render it most unsuitable for mounting many delicate tissues which are so frequently placed in it, thereby becoming almost invisible. There are several aqueous fluids, which

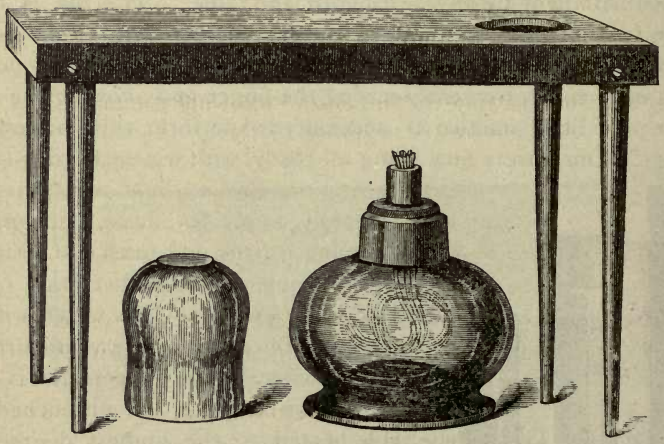


Fig. 16. Mounting Table with Lamp.

are far better suited to showing well the structure and beauties of innumerable objects, and these will be treated of in future papers. But their successful use, and the preparation and finishing of a permanent cell, containing them, requires a degree of skill to which the student can only attain by persistent efforts, and many failures; I have, therefore, thought it best to ground him well in the easier methods of balsam mountings,before proceeding to the higher plains.

In the next paper, therefore, I propose to treat of Dry Mounts, many of the preliminary processes of which are identical with those required for fluids, and which will serve to lead up to the latter. A worker who can make his balsam mounts, neatly and without failures, and consequently without saying or *thinking* naughty words, has certainly passed over the roughest portion of his journey, and may look with confidence for a continuously easier road, no matter in how many different directions it may lead him.

III.

IT is a matter of regret, I think, to those who have taken the trouble to think at all about the matter, that in our microscopic work, the efforts of almost all observers and workers are mainly devoted to such preparations as require, at least, moderately high powers and carefully arranged transmitted light for proper showing. Doubtless this is the only method by which we can hope to obtain any knowledge of the real structures of tissues, animal or vegetable, or of inorganic substances, such as rocks; but there are thousands of objects in the limitless realms of nature which will afford instruction and delight to the most indifferent of observers, who view merely their exteriors with a low power. Many of those require neither preparation or mounting, being too common or abundant to repay the slightest labor bestowed upon them. Others, however—and their name is legion—can and should be preserved in some permanent manner, readily accessible, and easily arranged for examination. In the vegetable kingdom we are presented with an endless and charming variety of beautiful forms in the seeds of even our commonest flowers, or even weeds, whilst the feathers, scales and hairs of the animal afford a never ending storehouse of treasures for the seeker after the curious and beautiful. The pollen from the tiniest flower, or the sands from the shores of the mighty ocean, alike present us forms and colors of surpassing beauty; and the preservation of these in a permanent form is at times most desirable. It shall be the purport of the present paper to point out some plain methods of doing so, which will produce good results if carefully followed.

Let us term this method of mounting "The Dry Way," to distinguish it from those preparations made in aqueous or other fluids, and proceed to make our mount in one of the several ways whereby it may be done. The books have been filled with such for years, good, bad, and indifferent. We have had full discussions of the merits and demerits of cells, possible and impossible; some made of shel-

lac, turned upon a whirling table with the point of a pen-knife, at an immense expenditure of time and patience; others of wax, bone, tin, hard and soft rubber, curtain rings, and a host of other substances; anything, in fact, but those, or rather *that* possessing the one quality needful for a dry cell, namely, the quality of remaining dry. For be it distinctly understood, that though a cell may be made and hermetically sealed, in which no appearance of moisture will ever occur, such an event is an anomaly and can never be duplicated with any certainty. No matter how dry the specimen may appear to be, nor the atmosphere of the room or the surface of the covering glass, sooner or later the under side of latter will become covered by a mist like substance, which obscures and spoils the view of the imprisoned specimen. This of course is the case only with such preparations, as are mounted on the bottom of a cell of any depth, the cover being used merely as a protection from dust and other injury. Where diatoms, the scales of insects, or other minute objects are mounted directly upon the under surface of the cover itself, this cloudy or watery appearance is either never observed at all, or else in so slight a degree as to cause no annoyance. When it does occur in a cell such as is usually used, and for the preparation of which the books give us so many elaborate directions, the only remedy is to remove it, (broken of course,) and replace with a fresh one; the latter in due time being predoomed to share a like fate.

"Is there no remedy for this," you will ask, and I answer unhesitatingly yes, if you will sacrifice your artistic cells of wax or what not, with their pretty colored rings of varnish, and be content with those of humbler but far more useful qualities. Paper, from which such dissimilar articles are now manufactured, as love letters and car wheels, is our friend in need in this emergency. Not sized or glazed or calendered, but soft, porous paper of various thicknesses, to suit our needs; a thick blotting pad being exceedingly useful, for cells containing objects sufficiently thick to require such a depth. If a still deeper cell than this be needed, then a slip of wood, 3x1 inches, and the thickness of an ordinary glass slide, with a hole bored through the middle is most useful; and here again comes in our friendly paper to form the bottom, all of which will be dwelt upon in due course.

The requisites then, for our dry mounting in the manner to be

described, are as follows: Crown glass slips of the usual dimensions, 3x1 and of moderate thickness, with cut edges, (grooved or smoothed ones are a needless expense), wooden slips of the same dimensions, with holes through their centres ⅝ to ¾ of an inch in diameter; covers of medium thickness, circles or squares as you prefer,—the latter being cheaper and equally good as the former; a supply of porous paper of various thicknesses from that of thick writing to a blotting board, two punches ⅝ and ¾ inches in diameter, some thin card board, covered with dead black paper, to form the bottom of the cells when the wooden slips are used, and a supply of colored paper for the backs and edges of the slides, with bronzed or figured ones for the fronts of same. These latter may be purchased of any optician at a small outlay and are made purposely, in very neat and pretty patterns. Labels, of course, oval or round, as one fancies and the tools and materials we have gathered together in our balsam mountings will suffice to give us a very pretty outfit wherewith to commence work on our dry mounts.

What shall we commence with? Here are some lovely little seeds, it may be of the portulaca, or the common chickenweed. Finding their diameter to be a little less than the thickness of our blotting pad, we will determine to make our cell of the latter, and so proceed to stamp a hole in a portion thereof with our ⅝ in. punch, after which we cut out a square of ⅞ in., leaving the hole in the center. Before attaching this cell to the glass slip a dead black bottom must be made for it, and this is best done by pasting a strip of the thin black paper upon the slide. And here let me say that the best and most satisfactory paste for this and all subsequent processes I have ever used is made with ordinary wheat starch, boiled, and beaten to the consistency of thick cream. It adheres tenaciously to glass, wood or paper, and seems to have no tendency whatever to absorb moisture from the surrounding atmosphere.

The black paper having been pasted upon the slide, the cell is in its turn to be pasted upon the paper so that its center shall be precisely in the centre of the slide, when a weight should be placed upon it until dry, and firmly attached. The seeds may be attached to the bottom of the cell by means of shellac cement, or liquid glue. Still better and in every way satisfactory is a cement made by dissolving a small quantity of shred gelatine in cold water, gently heating it after being dissolved. This should be made in small

quantities as wanted, since it will not keep. It is tough and very tenacious, and does not dry too quickly, excellent qualities in a cement for such purposes. Use only a sufficient quantity to attach the specimen firmly; any superfluity makes an unsightly blotch in the mount. The cleansed glass cover is now to be cemented on, with the same paste, when we are ready for the finishing.

The best colors for the covering papers are a bright canary for the black, and a red with gold bronze figures for the front, and these are the kind usually found on sale at the opticians.* The back should be pasted on the under side of the glass slip and turn up over the sides and ends on to the upper side of the same, over which it should extend for an eighth of an inch all around. Then the red and gold front with a 5/8 in. hole previously punched in the centre is to be pasted smoothly over the whole, equi-distant from the edges all around. The labels—usually plain white ovals,—are to be placed upon each end, when the appearance of the whole mount will be extremely neat and handsome, and the maker's mind need bear no troubles as to its future. Should any appearance of moisture under the cover be seen (which is not at all likely), a slight warming over the lamp will dispel the same, and leave all in pristine brightness.

Should our specimen be too bulky or thick to be contained within the shallow depths of a cell made of the thickest blotting pad, we must have recourse to the wooden slips, which will be found to form a cell deep enough for any mounting one may ever desire to make. The method of so doing is precisely the same as that followed with the glass slip, excepting that we must paste a strip of cardboard, covered with the dead black paper, on the under side of the slip to form the bottom of the cell. The slide is to be covered with the papers, and labeled exactly the same as though it were of glass.

Should the black paper not be readily procurable, a very excellent dead black for the bottom of the cell may be made with common lampblack water color, which dries with a dead surface very agreeable and pleasant for mounting foraminifera and similar objects upon. If a little gum arabic be mixed with the water, and the specimen placed upon the surface of the paint whilst still moist, it will be found that the latter will form an excellent cement, as well as background for holding the preparation.

* The writer regrets that the illustrations intended for this article have not been finished by the engraver in season to appear with the letter press.

Illumination by means of a lieberkuhn, which throws the light directly down upon the object without shadows, has been too much neglected. In England it is a very ordinary method of viewing opaque objects, and a lieberkuhn is usually furnished with every object-glass from a three inch to a four-tenths. But it is different here, and I am quite sure that the great majority of our observers, professional and amateur, are totally unacquainted with its use. I think this is to be regretted, since they lose much, both in pleasure and instruction from its non-employment. Hoping that its use may become more general, I will give a hint or two as to the method of mounting a preparation, to be examined by this form of illumination.

The lieberkuhn is a concave speculum fitting over the mounting of the objective so that the front lens of the latter projects through the middle of the lieberkuhn. Parallel rays of light are thrown upwards from the surface of the plane mirror, which being received upon the concave face of the lieberkuhn, are in turn reflected downwards upon the object under view. The foci of the objective and lieberkuhn being coincident, it follows that when the specimen under view is brought precisely into that of the former, its illumination by the latter is at the best. The central rays of light, however, coming immediately beneath the object, must be stopped out by some opaque background to insure the best effect. There are many modes of effecting this, and most of them involve the use of the various cells, which are hermetically sealed. These having been described at length by many more capable writers, I shall confine myself to the one method whereby our porous paper medium may be employed. For this purpose we shall need no additional tools or materials, save a large punch, say ⅞ inch, and some small circles of thin glass of ¼ to ⅜ inch in diameter. Placing a glass slip upon the turn table, we proceed to paint a disc, (very slightly larger than the circle of glass to be used), exactly in its centre. This is to be done with asphalte or Brunswick black, and the slide set aside for the same to harden, which it will do in an hour or two, or, if necessary, may be hastened by heating gently over the lamp or on the brass table. A second coating of the asphalte is now to be applied, and a circle of thin glass slightly warm is to be placed upon its surface with the forceps and gently pressed down to exclude air and cause perfect adhesion over its entire under surface.

We have now a perfectly opaque stop, with a clean glass surface, into which the most delicate object cannot sink and be lost, as is always the case if mounted directly upon the surface of asphalte, without the intersection of the thin glass. Bear this carefully in mind, and always use the glass circle if you wish to insure your preparation against disappearance in a black sea of death with the first hot spell.

The subsequent proceedings are almost the same as those first described in the present paper. The cell is to be made with the large punch, so as to leave ample space for the rays of light from the mirror to pass between its inside edges and the central stop, upon which the specimen is to be mounted. If one thickness of the paper or blotting pad be not sufficient, a second or third may be pasted upon it, until the desired depth is reached. And, of course, the covering paper for the back must be punched to allow the light to pass up, and not be put on solid, as mounts for ordinary opaque illuminations are. The object is best attached to the glass circle by means of the gelatine cement, and the slide is to be finished precisely the same as heretofore directed. And finally, all fears of moisture spoiling a beautiful preparation in the future may be dismissed as groundless.

Our work thus far has been confined to opaque objects requiring surface illumination, and it may be said that the great majority of all to be mounted in the dry way are of this class. But many, notably scales and hairs of insects, and plants, many diatoms, sections of pith, etc., are best viewed in the dry state and by transmitted light. Most of these may be mounted upon the cover, (the method of doing so in the case of diatoms, having been given in a former paper), and thus may be mounted in an ordinary cement cell without fear of moisture. The most satisfactory cement for this purpose (and most others), in my experience, is the white zinc, when properly prepared. It dries quickly, has no tendency to run in, and makes a beautiful finish to a mount. It should be used as follows, and the same directions will apply to asphalt or Brunswick black, if those cements be preferred.

Let us suppose that a ⅝ inch cover is to be used. Placing our glass slip upon the turntable, we proceed to run a ring of cement about its centre, the outer diameter of which shall be slightly in

excess of 5/8 inch, the width of the ring being about 1/8 of an inch. This first coat must be allowed to harden thoroughly, as on this depends all future success of the mount. If the slightest softness is left, it will be sure to yield still further in hot weather, and by capillary attraction run in and spoil the slide. To insure against all possibility of failure, let the slide be set aside for at least 48 hours, or else be baked in an oven. When the cover is ready to be place upon it, a fresh ring of the cement is to be run upon the top of the first, extreme care being taken not to let the fresh extend to the inner edge of the old cement, lest it run in by contact between the surfaces of slide and cover. The latter is then to be placed upon the ring, centered with the forceps, and slightly pressed down. A very thin coating of the cement is now to be applied around the edge, and allowed to harden, after which as many may be applied, with or without colored rings, as the taste of the worker dictates.

I find that the limit of my paper is reached without having exhausted the subject of which it treats, and the further consideration thereof must be left to a future one. In my next paper, therefore, I shall hope to finish this, and, at least, make a commencement on mounting in fluids, a subject that I regard as far more important than either balsam or dry mounts, and one in which practical hints, the result of many years of experience, may prove of more value to the beginner than anything I may have heretofore offered.

It may not be amiss to say, in concluding the present paper, that I have lately, after a long series of experiments, succeeded in perfecting an attachment, applicable to any microscope, whereby negative enlargements of all objects not requiring a greater power than 1/4 of an inch, may be readily and perfectly made by any one, even totally unacquainted with photography, and from these positives printed for throwing upon the screen with a lantern; at an infinitesimal cost of money and time. The whole process is performed by the simple aid of an ordinary coal oil lamp, neither Heliostat or any other costly form of illumination being required. I shall hope to describe and illustrate this apparatus in an early number of this magazine.

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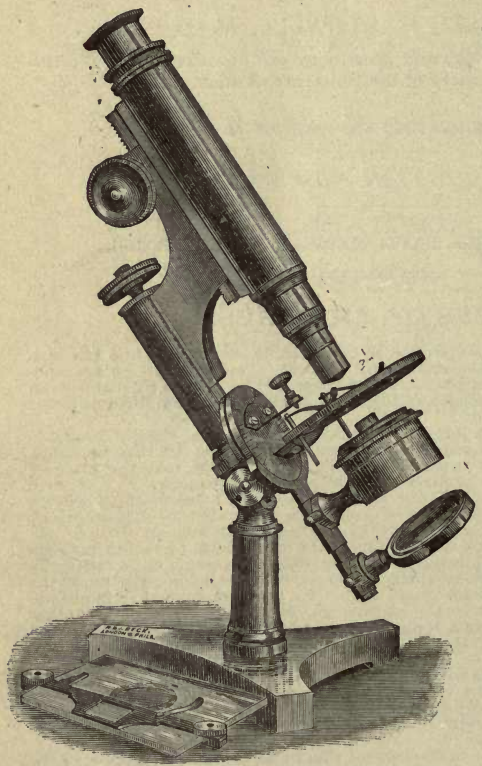

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